6.0 EFFECTS OF PROPOSED ACTION

6.1 ANALYTICAL METHODS

The proposed action has been evaluated using the five-part approach for applying the ESA jeopardy standard to Pacific salmon developed in Section 1.3.

6.1.1 Methods for Evaluating Effects on Action-area Biological Requirements

6.1.1.1 Methods for Upriver ESUs

6.1.1.1.1 Adult Fish Survival

The cumulative loss for adults migrating up the Columbia and Snake rivers through the FCRPS projects can be calculated as the difference in adult counts between dams (after adjustments for legal harvest and tributary turnoff). Adult loss, calculated this way, represents both mortality and apparent loss. Mortality can be related to passage through the dams and to other factors as well, such as illegal harvest, predation, gill-net interactions, and disease. Apparent adult loss between dams may be due to factors other than mortality, such as counting errors, double-counting adults that fall back and reascend ladders, and straying and tributary turnoff. A more reliable method to estimate adult passage loss is through the use of data from adult radio-tracking studies. This method rules out the double-counting error associated with the dam count method because it monitors the passage behavior of specific individual adults. Even with this method, however, many adult losses are not accounted for. For instance, there may not be any indication of a tagged adult's final fate, other than that it did not arrive at the next upstream dam. This unaccounted-for loss of the adult may be due either to mortality or to straying and tributary turnoff, but not to the counting errors inherent in the use of dam adult counts. The use of individually coded adult radiotelemetry tags greatly increases the precision associated with studies of adult migration behavior at dams and survival through the mainstem corridor (NMFS 2000e, p. 94).

While uncertainty is associated with the final fate of many radio-tagged adults, NMFS considers the unaccounted-for adult loss estimate calculated from these studies to be more representative of the mortality rate that may be associated with passage through the FCRPS dams than an adult loss estimate based on the comparison of adult counts between dams (NMFS 1995a). Therefore, data from radio-tagging studies, when available, were used to estimate the unaccounted-for adult loss rate and, as a corollary, the minimum survival rates of adults during passage through the hydrosystem. These estimates are considered minimal because some radio-tagged adults may have survived, but were not accounted for. Minimum survival rates were derived by dividing the number of radio-tagged adults detected at an upstream dam by the number of adults tagged minus the number of fish accounted for in the study. Where multiyear study data are available for a particular species, the multiple-year results are averaged. The mean unaccountable loss rate in the multiyear project and reach studies, the mean minimal survival rates (1-loss), and the per project survival rates are shown in Table 6.1-1.

6.1.1.1.2 Juvenile Fish Survival

The primary method for evaluating the effects of the proposed action on migrating juvenile salmonids in the mainstem Columbia and Snake rivers was through simulation modeling. The Biological Effects Team[1] used NMFS' SIMPAS model to evaluate the biological effects of current FCRPS facilities and operations and the likely benefits of potential measures to improve juvenile salmonid passage survival. This spreadsheet model, developed by NMFS' Northwest Region Hydro Program staff, is a fish passage accounting model that apportions the run to various passage routes (i.e., turbines, fish bypass system, sluiceway/surface bypass, spillway, and/or fish transportation) based on empirical data and assumptions for fish passage route use. The model then accounts for "successful fish passage" (survival) and "losses" (mortalities) through each of the alternative passage routes to estimate total survival past each project. The model also accounts for dam plus pool survival, the proportion of juvenile fish transported, the proportion left to migrate inriver, the system survival of inriver and transported fish combined, and the survival of inriver fish alone.

The Biological Effects Team reviewed and analyzed fish passage assumptions used by NMFS in earlier fish passage modeling exercises, those developed in the PATH process, and the most recent empirical data information to determine the fish passage parameters for input into the SIMPAS model. The team also used the latest compilation of fish passage information in the four white papers recently prepared by the Northwest Fisheries Science Center on 1) "Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dams," 2) "Predation on Salmonids Relative to the Federal Columbia River Power System," 3) "Salmonid Travel Time and Survival Related to Flow in the Columbia River Basin," and 4) "Summary of Research Related to Transportation of Juvenile Anadromous Salmonids Around Snake and Columbia River Dams" (NMFS 2000e,f,h,i). Detailed descriptions of the SIMPAS model and the results of various simulations are provided in Appendix D.

[1] Since late 1999, NMFS has been engaged in ESA Section 7 consultation with the Federal Action Agencies (the Corps, BOR, and BPA) to develop a biological opinion on the effects of the Action Agencies' proposed action and future operation and configuration of the FCRPS projects. To facilitate completion of the Section 7 consultation process, the Federal agencies formed five action teams during January 2000, including the Biological Effects Team.

Table 6.1-1. Estimates of minimum adult survival and unaccounted loss based on radio-tracking studies through the FCRPS projects.

	Adult Loss					Current Condition			
	Multiyear/Project Radio-tracking Studies		Single-year Reach Studies						
	1995 BiOp	1998 BiOp	RT 96[1]	RT 97[1]	RT 98[1]	Mean Loss[2]	Minimum Mean Survival[3]	Number of Dams	Per-Project Survival[4]
Chinook Salmon									
SR spring/summer chinook	0.209[5]	0.252	0.161	0.158	0.130	0.175	0.825	8	0.976
SR fall chinook	0.393				0.187	0.290	0.710	8	0.958
UCR spring chinook[6]							0.907	4	0.976
LCR spring chinook[6]							0.976		0.976
LCR fall chinook[7]							0.958	1	0.958
Steelhead									
SR steelhead		0.208	0.270	0.204		0.227	0.773	8	0.968
UCR steelhead[8]							0.878	4	0.968
MCR steelhead[8]							0.878	4	0.968
LCR steelhead[8]							0.968	1	0.968
SR sockeye salmon	0.154[9]			0.132[10]		0.143	0.857	8	0.981

[1] T. Bjornn, pers. comm., November 2000 (data from 1996, 1997, and 1998 radio-tracking [RT] studies).
[2] Average of 1995 and 1998 Biological Opinion and radio-tracking studies.
[3] 1 minus mean loss.
[4] Calculated by taking the nth root of the number of dams (n) passed minimum mean survival estimates.
[5] Not included in loss/survival estimates (1998 Biological Opinion estimate is an update of the 1995 Biological Opinion estimate).
[6] Calculated from SR spring/summer chinook salmon per-project survival rates.
[7] Calculated from SR fall chinook salmon per-project survival rates.
[8] Calculated from SR steelhead per-project survival rates.
[9] Based on count analyses (1985 to 1994) (1995 Biological Opinion).
[10] Sockeye passage to Wells Dam.

6.1.1.2 Application to All 12 ESUs

The methods described above are applied to the relatively robust empirical data sets for SR spring/summer chinook salmon (yearlings), SR fall chinook salmon (subyearlings), and SR steelhead migrants. The results are applied to the remaining chinook salmon and steelhead ESUs for which empirical data are lacking. Because juvenile survival studies do not exist for CR chum salmon, mixed-stock LCR fall chinook salmon were used to estimate passage survival through the Bonneville project for this ESU. No adult fish passage studies are available for CR chum salmon. Because juvenile survival studies either do not exist or are inadequate for this purpose, passage survival for sockeye salmon cannot be evaluated for this ESU.

NMFS assesses the effects of the proposed action on action-area biological requirements in a qualitative manner for all 12 ESUs, and the effects of the proposed action on critical habitat types (i.e., juvenile rearing areas, juvenile migrations corridors, areas for growth and development to adulthood, adult migration corridors, and spawning areas) in the action area. The purpose of the evaluation is to determine whether any of the constituent elements of critical habitat are likely to be adversely modified or destroyed under the proposed action.

6.1.2 Methods for Evaluating Effects of Hydrosystem Actions on Species-level Biological Requirements

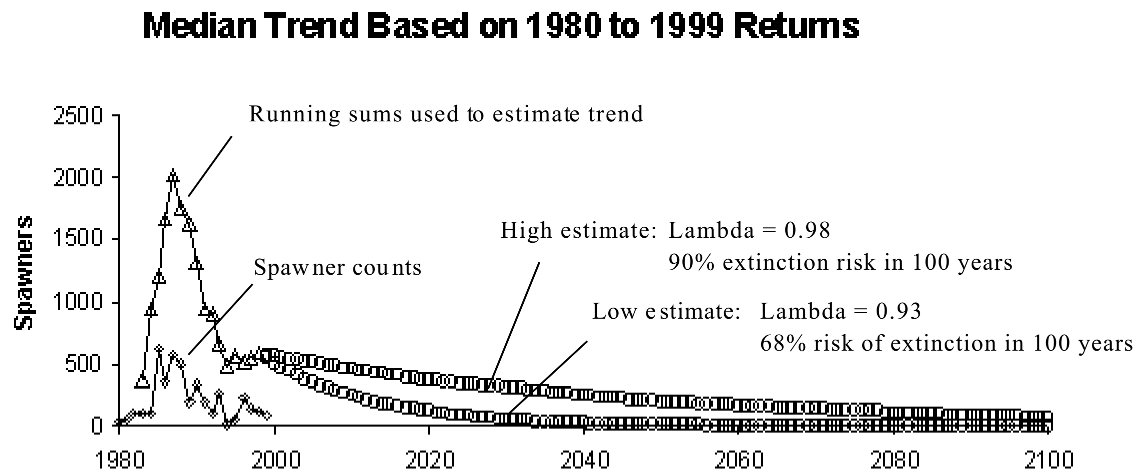
The effects of the proposed action in the action area (Section 6.1.1) must be evaluated in the context of survival throughout the life cycle and compared with the jeopardy standard described in Section 1.3.1.1. NMFS uses the methods presented in this section to perform the analyses called for by Steps 3 and 4 of the Jeopardy Analysis Framework discussed in Section 1.3, above. For all ESUs except SR sockeye salmon, a combination quantitative and qualitative approach was applied. The quantitative analysis attempted to capture most of the effects of the proposed action and of likely actions affecting other life stages, but in all cases complementary qualitative analyses were also necessary. For SR sockeye salmon, only a qualitative approach was possible.

Briefly, the quantitative analysis is described in the first four steps illustrated in Figure 6.1-1. A more detailed description of the quantitative analysis is found in Appendix A. Details specific to each ESU are described in Section 6.3. The qualitative approach is described in the fifth step. Following is a summary of the five-step method of evaluating effects of the proposed action on species-level biological requirements.

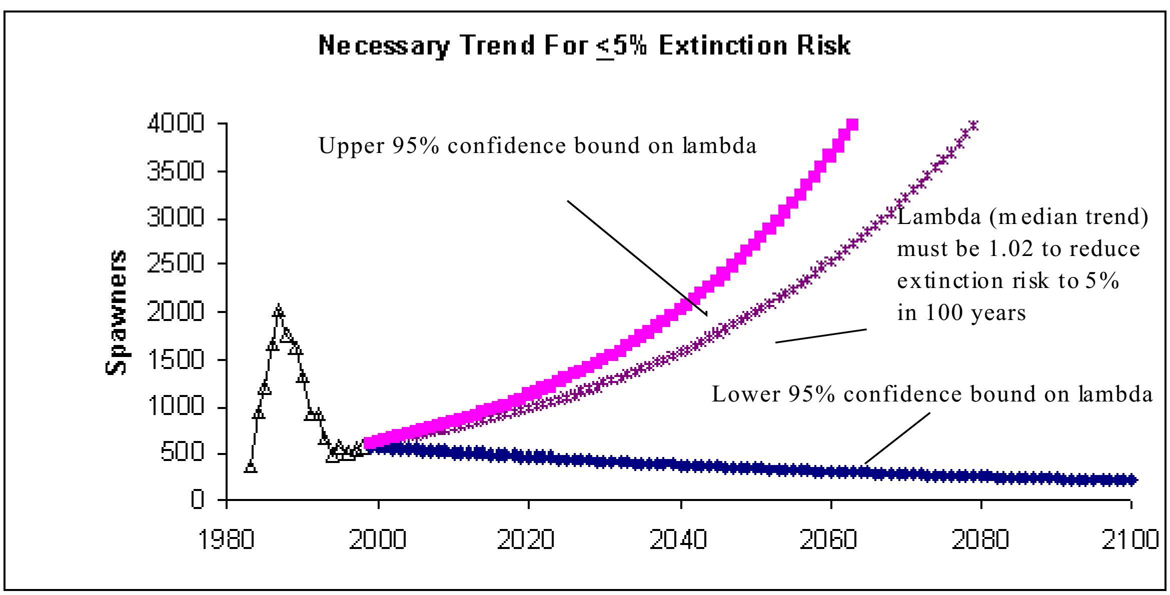
1) Define the recent population trend, based on adult returns from 1980 through the most recent year available. The starting point is the NMFS CRI analysis for 11 ESUs (McClure et al. 2000a,b,c) and the NMFS QAR for the two Upper Columbia River ESUs (Cooney 2000). These reports assess population trends, based on adult returns during recent years. The trend is defined as the median annual population growth rate (lambda). This is estimated in the CRI analysis by methods described in McClure et al. (2000c) and Holmes (in review). Simply put, the analysis fits a stochastic exponential decline curve to running sums of total living current or future

Figure 6.1-1. Primary steps in the analysis of effects of the action on species-level biological requirements for a hypothetical salmon population. Lambda is the median annual population growth rate.

1. Define the recent population trend, based on adult returns from 1980 through the most recent year available.



2. Define the change in trend that is necessary to meet the survival and recovery indicator criteria described in Section 1.3.1.

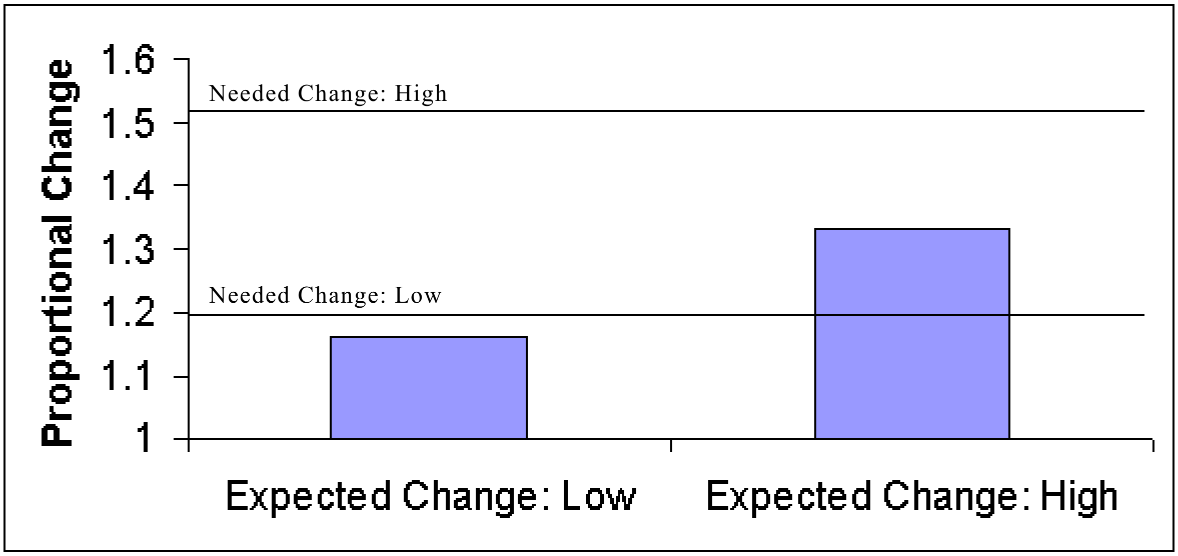


$$\text{Low Needed Survival Change} = \left(\frac{\text{Needed Lambda} = 1.02}{\text{Current Lambda} = 0.98}\right)^{\text{Mean Generation Time [4.5]}} = 1.20$$

$$\text{High Needed Survival Change} = \left(\frac{\text{Needed Lambda} = 1.02}{\text{Current Lambda} = 0.93}\right)^{\text{Mean Generation Time [4.5]}} = 1.52$$

Figure 6.1-1 (Continued). Primary steps in the analysis of effects of the action on species-level biological requirements for a hypothetical salmon population. "Lambda" refers to the median annual population growth rate.

3. Estimate the change in survival rates associated with the proposed action and with expected changes in other life stages and update the estimate of population growth rate.



4. Compare the change in survival resulting from the proposed action with the necessary change defined in step 2.

   - In the example, the highest estimate of the expected survival change achieves the lowest estimate of the goal but the lowest estimate does not. In the worst case, an additional 31% (1.31 times "Low" expected survival rate) survival improvement is still necessary to meet the highest estimate of the goal.

6. Qualitatively evaluate the likelihood that survival through life stages that could not be quantified is likely to sufficiently reduce the additional necessary survival change.

   - Relies on information in Basinwide Recovery Strategy spawners. Cooney (2000) estimates population growth rate using a stochastic simulation model fit to adult spawner-to-spawner data.

Since the primary purpose of the analysis is to determine the status of stocks and the risks they face under current conditions, NMFS restricted it to the years since 1980. Several agencies and organizations commented on the July 27 draft biological opinion that NMFS should have included earlier starting years in its estimation of population trends. Changes to the hydrosystem were a main component of the choice of 1980 as the starting year, since before then, the hydrosystem on the Columbia River was in a state of flux. The final dam on the mainstem Columbia was completed in 1971, the last of the four lower Snake River dams was completed in 1975, and the full complement of turbines was installed by 1979. The reservoir storage capacity in the Columbia was nearly doubled in 1975, when Libby and Mica dams were completed. Including data from before 1980 would, therefore, confound the evaluation of the current status by implicitly incorporating conditions that no longer exist. The evaluation would also be confounded for other reasons, such as the oceanic regime shift that occurred in the late 1970s (Mantua et al. 1997).

Agencies and organizations commented on the choice of median annual population growth rate as the measure of current trends in the July 27 draft biological opinion (NMFS 2000b) and the anadromous fish appendix. Commenters expressed computational concerns and confusion because NMFS' methods for estimating lambda have changed. Many of the suggestions are reflected in the current analysis. The exact methods are now available in McClure et al. (2000c) and Holmes (in review). Some agencies and organizations suggested alternative indicators of population trend, such as recruits per spawner (R/S) and smolt-to-adult returns (SARs). Use of median annual population growth rate yields results nearly identical to R/S if recruits are defined as adults reaching the spawning grounds. Use of R/S with recruits expressed at other life stages, such as adults to the Columbia River mouth, and use of SARs yields estimates of trend for only part of the life cycle. Unless survival is assumed constant in the other life stages, these measures are not useful for assessing population trends.

NMFS also received comments that the annual population growth rate, as determined in McClure et al. (2000b), is very sensitive to the time period selected for the analysis and to data points considered "outliers." NMFS applies running sums to the abundances, which reduces the influence of individual years. However, NMFS agrees in general with the comment. In response, NMFS developed an alternative method of estimating the mean that is less sensitive to these factors. The difference between the more robust and previous estimates of annual population growth rate vary, but for 80% of all spawning aggregations, the two estimates differ by an absolute value of less than 0.05 (McClure 2000). Whereas this method eliminates the sensitivity to time period (or outliers), the implications for estimates of extinction risk, which are sensitive to the distribution of the data, are not well understood. Additional research is needed to determine whether this method, or an alternative, best addresses the sensitivity of NMFS' analytical method to start and end points and extreme values. Therefore, NMFS has not used this new method in this biological opinion, but considers this characteristic of the analysis qualitatively when drawing conclusions.

2) Define the change in the trend that is necessary to meet the survival and recovery indicator criteria described in Section 1.3.1. Both McClure et al. (2000b,c) and Cooney (2000) estimated the proportional change in population growth rate necessary to reduce extinction risk to 1% in 24 and 100 years. That change in population growth rate can be translated into a needed change in survival if the mean generation time is known:

$$\Delta S = \Delta \lambda^{\text{mean generation time}}$$

where $\Delta\lambda$ is the multiplicative change in median annual population growth rate (based on 1980 to most recent available year) and ΔS is the multiplicative change in average egg-to-adult survival, or survival during any component life stage, that corresponds to the return years used to estimate $\Delta\lambda$.

McClure et al. (2000b,c) used diffusion approximation methods (Dennis et al. 1991; Holmes in review) to project future population trajectories and estimate extinction risk for the survival indicator criterion. Cooney (2000) used a cohort replacement model (Botsford and Brittinacher 1998) to do the same. Neither approach includes density dependence at the low population levels evaluated in the estimation of extinction risk. A few agencies and organizations that commented on the July 27 draft biological opinion suggested including density dependence at low population levels, and the Idaho Department of Fish and Game suggested including depensation at low population levels. NMFS' assumption of density independence at low population levels is more conservative (i.e., results in higher risk of extinction) than models based on density dependence, such as those based on Ricker functions. A model based on depensation may yield more conservative results, but parameterization of such a model for the populations under consideration must be based almost exclusively on guesswork.

NMFS evaluated the recovery indicator criteria for stocks with interim recovery abundance levels using either simulations with the cohort replacement model for UCR stocks (Cooney 2000) or with an estimate of the minimum change in survival that would be necessary to grow from the current abundance level to the recovery abundance level in either 48 or 100 years (Schiewe 2000a; Appendix A). The first method includes assumptions regarding density dependence as populations approach the recovery abundance level; the second method assumes continued exponential growth near recovery abundance levels. Several agencies and organizations, when commenting on the July 27 draft biological opinion, criticized the absence of density dependance at high abundance levels using this second approach. NMFS agrees that density dependence probably occurs at some high abundance level. The difficulty is in defining the capacity of the system and the rate at which productivity declines as that capacity is approached. NMFS has been unable to detect density dependence in the period since 1980 for Columbia basin stocks (McClure et al. 2000c) and questions the data quality and conclusions from analyses that have been based on longer time-series (Schaller et al. 1999; Zabel and

Williams 2000; Schaller et al. 2000). Therefore, with the exception of the QAR analysis for UCR spring chinook and UCR steelhead, analysis of the survival changes necessary to meet recovery indicator criteria do not include density dependence. However, NMFS qualitatively considers the likelihood that these are minimum estimates in its jeopardy determination.

NMFS applies a simple method of estimating the minimum survival change necessary to meet the recovery indicator criteria for stocks lacking an interim recovery abundance level. As described in Section 1.3.1, the recovery abundance level may be unknown, but it is certainly higher than the current abundance level. Therefore, at a minimum, the median annual population growth rate must be ≥ 1.0. This is determined by simply dividing 1.0 by the estimate of lambda from the first step of the analysis.

3) Estimate the change in survival rates associated with the proposed action and with expected changes in other life stages and update the estimate of population growth rate.

The necessary survival changes identified in the second step of the analysis are based on the assumption that life-stage survival rates influencing adult returns in 1980 through the most recent available year will continue indefinitely. However, the survival rate associated with the proposed action may represent an improvement over the average survival rate influencing 1980-through-most-recent adult returns. Current survival in other life stages may also differ from the 1980-through-most-recent-year average. If these current or expected survival rates are expected to continue, they will change the population growth rate.

NMFS estimates FCRPS juvenile survival and adult survival resulting from the proposed action using the methods defined in Section 6.1.1. The change for each species is addressed separately for each ESU. In some cases, retrospective modeling analyses are available for comparison (e.g., PATH juvenile passage survival estimates for SR spring/summer and fall chinook). In other cases, inferences must be drawn from other species or geographic areas. NMFS also estimates expected survival associated with current and future harvest rates, based on actions defined in the Basinwide Recovery Strategy, and compares that with average historical harvest rates. The combined change in survival is simply the product of the survival change expected from the proposed action and that expected from current harvest rates. For example, if the average smolt survival through the hydrosystem averaged 50% for the migration years corresponding to the risk assessment and it is expected to be 55% as a result of the proposed action, a 10% survival improvement is expected (0.55/0.50 = 1.10). If current and future harvest management results in a 5% survival improvement, the combined change is 15.5% (1.10 x 1.05 = 1.155).

NMFS was not able to quantify expected changes in survival resulting from habitat and hatchery management actions in this analysis. Those effects are evaluated qualitatively in relation to the remaining survival change needed after implementing the proposed action (see below).

The analysis of survival changes used in this biological opinion is identical to that used for SR steelhead in the July 27 draft biological opinion and for the evaluation of alternative harvest strategies in McClure et al. (2000c), but is simpler than the Leslie matrix approach that was applied to other ESUs (Leslie 1945, 1948). The primary reason for the change is that applying the Leslie matrix requires an estimate of survival through all life stages, while the method used here requires only estimates of survival changes for life stages that are affected by the proposed action, or that have been affected by changes in other management actions. The matrix approach in the July 27 draft biological opinion is useful (Kareiva et al. 2000; Cooney 2000), but it is unnecessarily complex for the analysis required in this biological opinion. Technical discussions on the July 27 draft sometimes focused on estimating survival rates that were not critical to the results and generated debates regarding differences between estimates of population growth rate from the deterministic Leslie matrix and the stochastic modified Dennis model approach. The current method simply updates the original estimate of median annual population growth rate (λ) according to a generalized form of Equation 11 in McClure et al. (2000c):

$$\lambda_{NEW} = \lambda_{OLD}(\text{new life-stage survival rate/old life-stage survival rate})^{1/\text{mean generation time}}$$

4) Compare the change in survival resulting from the proposed action with the necessary change defined in step 2. NMFS constructed ratios that indicate the degree to which the proposed action meets the survival and recovery indicator criteria. Ratios less than, or equal to, 1.0 indicate that the jeopardy standard indicator metrics are met, given the effects of the proposed action and other expected activities. Values over 1.0 indicate that additional improvements in survival are necessary to meet the criterion. Those values represent the multiplier by which survival, after the proposed action and other expected actions are implemented, must be additionally increased.

5) Qualitatively evaluate the likelihood that survival through life stages that could not be quantified is likely to reduce the additional necessary survival change. The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. NMFS must use a combination of qualitative methods and professional judgment to determine the extent to which changes in other life stages might account for the necessary survival improvements. Survival changes can be expressed as changes from the average 1980-to-1999 egg-to-smolt survival, estuary survival, and/or prespawning adult (above the uppermost dam) survival rates. Because the quantitative analysis does not include the effects of FCRPS operations on some life stages in some ESUs (e.g., spawning and rearing requirements of LCR chinook salmon and CR chum salmon), the effects must also be evaluated qualitatively. For SR sockeye salmon, this is the only type of analysis NMFS can perform, because the information available is not suitable for calculating an estimate of current demographic risks, let alone expected survival improvements under the proposed action.

The qualitative evaluation is, therefore, a key factor in the jeopardy determination for each ESU. Among the factors that NMFS will consider at this step are the effects of the proposed action on critical habitat in the action area (see above) in the overall context of all the effects on biological requirements throughout the life cycle. The evaluation draws on a review of the existing literature, including the information summarized in Section 4.1 and Appendix C. Adverse effects on individuals of a species or constituent elements or segments of critical habitat generally do not result in jeopardy or determination of adverse modifications unless that loss, when added to the environmental baseline, is likely to result in significant adverse affects throughout the species range, or to appreciably diminish the value of the critical habitat for both the survival and the recovery of the listed species (50 CFR Section 402.02). Therefore, NMFS considers the range of critical habitat types affected by the proposed action, the geographic scope of the effects, and the degree to which the effects are likely to limit the productivity of each ESU.

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6.2 EFFECTS OF FCRPS OPERATIONS—ACTION AREA BIOLOGICAL REQUIREMENTS

Development of the Pacific Northwest regional hydroelectric power system, dating to the early twentieth century, has had profound effects on the ecosystems of the Columbia River basin (ISG 1996). These effects have been especially adverse to the survival of anadromous salmonids. The direct effects of the construction of the FCRPS on salmon and steelhead in the Columbia basin can be divided into four categories: blockage of habitat; alteration of habitat; barrier to, or modification of, juvenile migration; and barrier to, or modification of, adult migration. Where no fish passage facilities have been provided, hydroelectric dams completely block anadromous fish runs on the river. In addition, dams inundate historical spawning and rearing habitat. For salmon and steelhead, much of this effect occurred with the construction of the Grand Coulee (1941) and Chief Joseph (1961) dams on the Columbia River and the Hells Canyon Hydroelectric Complex (1959) on the Snake River. More than 55% of the Columbia River basin accessible to salmon and steelhead before about 1939 has been blocked by large dams (NWPPC 1986).

Dams present barriers to the upstream and downstream migrations of anadromous fish. A significant rate of juvenile injury and mortality occurs during downstream passage. Physical injury and direct mortality result from passage through turbines, juvenile fish bypasses, and to a lesser degree, spill. Indirect effects of passage through all routes may include disorientation, stress, delay in passage, exposure to high concentrations of dissolved gases, exposure to warm water, and cumulative effects of the above. Although the direct mortality of adults is probably minimal during passage at individual dams, each dam presents the potential for delays at fishway facilities, energy expenditure in passage through multiple fishways, involuntary fallback, and, during periods of involuntary spill, increased exposure to high concentrations of dissolved gases.

The impoundments created by the FCRPS dams greatly increased the cross-sectional area in much of the Columbia and lower Snake rivers, reducing water velocity and water particle travel times in the impounded river reaches. Regulating water in upriver storage reservoirs modifies the natural hydrograph and affects the listed species throughout the action area, from the upriver storage reservoirs to the Columbia River plume. Water regulation reduces flow (volume per unit time) to less than what would naturally occur during spring and early summer.

Water regulation and impoundment also change water quality factors such as temperature and turbidity, as well as the production of salmonid prey. Reservoirs provide habitat for salmonid predators. Channel complexity is reduced, affecting fluid dynamics (e.g., ISG 1996) and substrate types. Load-following operations at hydrosystem projects (hourly and daily load-following and reduced weekend flows) can affect access to suitable spawning habitat and can trap and strand both adults and juveniles.

6.2.1 Effects on Habitat in Columbia River Mainstem, Estuary, and Plume

The lower Columbia River and estuary habitats have been affected over the past 60 years by the series of mainstem hydrosystem reservoirs and by the operation of upstream multipurpose storage projects. The impoundments have also inundated extensive salmon spawning and rearing habitat. Historically, fall chinook salmon spawned in mainstem reaches from near The Dalles, Oregon, upstream to the Pend Oreille and Kootenai rivers in Idaho and to the Snake River downstream of Shoshone Falls. Presently, mainstem production areas for fall chinook are confined to the Hanford Reach of the Columbia River, the Hells Canyon Reach of the Snake River, the mid-Columbia River, and below the lower Snake River projects and Bonneville Dam. The Hanford Reach is the only known mainstem spawning area for steelhead. Spawning habitat used historically by LCR chinook and CR chum salmon and by LCR steelhead was probably inundated by the Bonneville pool as well.

The mainstem habitats of the lower Columbia and Willamette rivers have been reduced primarily to a single channel: floodplains have been reduced, off-channel habitat features have been eliminated or disconnected from the main channel, and the amount of large woody debris in the mainstem has been greatly reduced. Finally, most of the remaining habitats are affected by flow fluctuations associated with reservoir water management for power peaking, flood control, irrigation, and other operations.

Large multipurpose storage projects, developed in both Canada and the United States, have altered the seasonal runoff pattern and volume of flow into the estuary. Recent model studies by Bottom et al. (2000) indicate that the volume and timing of water and sediment delivery have changed since the late 1880s due to hydrosystem operation, even after the effects of climate change and irrigation withdrawals are taken into account. Compared with the 1880s, current operations do the following:

1. Deliver more water to the estuary during winter (October through April) and less water during spring and summer.

2. Reduce the peak spring freshet by more than 40% and reduce total freshet-season flow volume by about 30%.

3. Lengthen the period of the freshet and move the peak flow earlier (by prereleasing stored water for flood control, which interacts with recent climate change).

4. Greatly increase fall-winter minimum flows.

In addition, the model studies indicate that the hydrosystem and climate change together have decreased suspended particulate matter to the lower river and estuary by about 40% (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50% or more. Overbank flow events, important to habitat diversity, have become rare – in part because flow management and irrigation withdrawals prevent high flows and in part because diking and revetments have increased the "bankfull" flow level (from about 18,000 to 24,000 m^3/s). The dynamics of estuarine habitat have changed in other ways relative to flow. The availability of shallow (between 10 cm and 2 m depth), low-velocity (less than 30 cm/s) habitat now appears to decrease at a steeper rate with increasing flow than during the 1880s, and the resilience of the estuary to increasing water depth with increasing flow (absorption capacity) appears to have declined.

The significance of these changes to salmonids is unclear. Estuarine habitat is likely to provide services (food and refuge from predators) to subyearling migrants that reside in estuaries for up to 2 months or more (Casillas 1999). Historical data from Rich (1920) indicate that small juvenile salmon (< 50 mm), which entered the Columbia River estuary during May, grew 50 to 100 mm during June, July, and August. Data from a more contemporary period (Dawley et al. 1986; CREDDP 1980) show neither small juveniles entering the estuary in May nor growth over the summer season.

The Columbia River plume also appears to be an important habitat for juvenile salmonids, particularly during the first month or two of ocean residence. The plume may simply represent an extension of the estuarine habitat. More likely, it represents a unique habitat created by interaction of the Columbia River freshwater flow with the California Current and local oceanographic conditions. Ongoing studies show that nutrient concentrations in the plume are similar to nutrient concentrations associated with upwelled waters. Upwelling is a well-recognized oceanographic process that produces highly productive areas for fish; primary productivity, and more importantly, the abundance of zooplankton prey, is higher in the plume compared with adjacent nonplume waters. Further, salmon appear to prefer low surface-salinity waters, as the abundance and distribution of juvenile salmon are higher and more concentrated in the Columbia River plume compared with adjacent, more saline waters. These findings support the notion that the plume is an important habitat for juvenile salmonids. What is not known is how Columbia River flows affect the structure of the plume during outmigration periods, and whether critical threshold flows are needed. Ongoing research will document important relationships between juvenile salmon growth and survival during this stage of their life history.

6.2.2 Effects of Project Operations on Juvenile Salmonid Passage—General Considerations

The presence of dams in the migratory corridor results in some migrational delay (Raymond 1969, 1979), thereby influencing migration speed and timing of juveniles. Dams also impede the safe passage of juveniles. Some juvenile mortality is associated with all routes of passage at dams, with the highest mortality occurring through turbines (Whitney et al. 1997) and lowest direct mortality through spillways (NMFS 2000e). Some passage routes have additional effects, such as the increase in TDG (water quality) caused by spill.

For SR and UCR chinook salmon and steelhead, an analysis of effects on survival is the primary method used in this biological opinion for evaluating the effects of the proposed action on the biological requirements of listed species in the action area. An important objective of project operations is to increase survival by routing a high proportion of juveniles past the projects in a manner that avoids passing them through turbines. The proportion of smolts that pass a project through bypass systems or over spillways—project fish passage efficiency (FPE)—varies by species composition and may vary within a season and between years for a single species with changes in smolt condition, environmental conditions, and project operations.

6.2.2.1 Juvenile Salmonid Passage Through Turbines—General Considerations

Turbine survival studies for juvenile passage published through 1990 at the Snake and lower Columbia River dams have been reviewed by Iwamoto and Williams (1993). The Independent Scientific Group (ISG 1996) and Whitney et al. (1997) reviewed studies published through 1995. Turbine mortality has been estimated primarily for juvenile salmon, although at least two studies have estimated steelhead mortality (Weitkamp et al. 1986; Olson and Kaczynski 1980). Whitney et al. (1997) pointed out that in studies where marked fish were immediately recovered in the tailrace, mortality estimates were less than 7% (average 5.5%). In studies with longer times between turbine passage and recovery, mortality levels averaged 10.9% (Whitney et al. 1997). Whitney et al. (1997) also suggested that the lower survival estimates probably included some level of mortality associated with predation on disoriented smolts after turbine passage. That is, turbine passage not only causes direct mortality but may also cause indirect mortality by increasing a fish’s susceptibility to predation.

6.2.2.2 Juvenile Salmonid Passage Through Bypass Systems—General Considerations

Estimates of the direct survival rate of juvenile salmon and steelhead through bypass systems include mortality rates associated with turbine intake screens, gatewells, orifices, bypass flumes, dewatering screens, sampling facilities (including holding tanks), and bypass outfall conduits. Although direct survival through mechanical screen bypass systems is higher than through turbines, fish transiting bypass systems often exhibit increased signs of stress (compared to control groups) as measured by blood chemistry, increased descaling, and possibly delayed mortality (NMFS 2000e). Estimates of direct bypass mortality found at sampling facilities for the bypass systems at the Federal hydroelectric projects on the Snake and lower Columbia rivers suggest that the direct mortality of wild yearling steelhead and chinook salmon is generally less than 1% (Martinson et al. 1997; Spurgeon et al. 1997; summarized in the 1998 FCRPS Supplemental Biological Opinion), although some level of stress or injury may result in mortality later in the life cycle. Bypass survival may be indirectly affected by predation at poorly located outfall sites or by delayed mortality associated with injury or stress caused by passing through one or more bypass systems.

6.2.2.3 Juvenile Salmonid Passage Through Spill—General Considerations

Whitney et al. (1997) reviewed 13 estimates of spill mortality published through 1995 (three for steelhead and 10 for salmon) and concluded that the most likely range in mortality for standard spill bays is 0% to 2%. However, the authors also pointed out that the presence of local conditions such as back-eddies or other features that provide refuge for predators may lead to higher spillway passage mortality. In general, relative to other passage routes currently available, direct juvenile survival is highest through spillbays (NMFS 2000e). Although the FCRPS is currently managed to meet TDG standards, concentrations may rise to levels that induce gas bubble trauma (GBT) in salmonids under high levels of involuntary spill, reducing the survival of both the juvenile and adult life stages. This concern emphasizes the importance of the physical and biological TDG monitoring programs at the Federal dams.

6.2.2.4 Juvenile Inriver Reach Survival—General Considerations

Williams et al. (in review) expanded the 1960s and 1970s estimates of direct survival of yearling salmonid migrants from the head of the upstream reservoir (Ice Harbor Dam through 1968, Lower Monumental Dam in 1969, Little Goose Dam from 1970 to 1974, and Lower Granite Dam since 1975) to the tailrace of Bonneville Dam, and compared these with expanded 1993-through-1999 estimates. During the 1960s, with four dams in place, direct survival of yearling migrant fish through the hydrosystem was 32% to 56%. Four more dams were constructed between 1968 and 1975. Estimates of system survival during the 1970s typically ranged from 10% to 30%, but were less than 3% for the drought years 1973 and 1977. During the most recent period, 1995 to 1999, system survival of SR spring/summer chinook salmon has ranged from 42% to 59%, substantially higher than during the 1970s and similar to 1960s levels. The recent increase is probably the result of good flow conditions combined with implementation of the project operations and fish passage improvements prescribed in the 1995 FCRPS Biological Opinion.

The rate of survival of subyearling fall chinook salmon through the hydrosystem is lower than that of yearling chinook salmon. During the 1995-through-1999 outmigrations, NMFS PIT-tagged Lyons Ferry Hatchery subyearling fall chinook salmon with passive integrated transponders (PITs) and released them above Lower Granite Dam. Survival from the point-of-release in a free-flowing reach of the Snake River to the tailrace of Lower Granite Dam averaged from about 55% for the earliest releases to about 13% for groups released in early July, coinciding with substantial increases in water temperature and decreases in flow and turbidity. These survival estimates incorporate the effects of mortality during rearing (i.e., from parr to active migrant stage) migration through free-flowing reaches, and migration through Lower Granite Reservoir and Dam. In the reach between the tailrace of Lower Granite Dam and that of Lower Monumental Dam (i.e., encompassing two dams and reservoirs), the survival of summer migrants was estimated within a season and for a given season, among years. Weekly estimates of survival averaged from about 11% to 68%, the lowest pertaining to releases later in the season, when environmental conditions were relatively poor (e.g., high water temperature, low flow, and low turbidity). Survival of run-of-the-river subyearling chinook salmon from the tailrace of McNary Dam to the tailrace of John Day Dam was approximately 41.0% and 77.5% in 1998 and 1999, respectively. Estimates of subyearling chinook salmon survival through this reach before the development of the hydrosystem are lacking and thus cannot be compared with recent estimates. However, recent estimates suggest that passage through the hydrosystem results in high mortality rates for Snake River subyearling chinook salmon during the summer, when environmental conditions deteriorate. One caveat to this conclusion is that, based on preliminary data, juvenile subyearlings detected in the Snake River for the first time during September and October have adult return rates that are approximately five times higher than those of subyearlings detected during summer.

6.2.3 Specific Effects of FCRPS Operations on Juvenile Salmonid Passage and Survival

6.2.3.1 Juvenile Salmonid Passage Through Turbine Units at FCRPS Projects

In recent years, evaluations of turbine mortality have been conducted under the turbine operations presumed to provide the best conditions for fish (i.e., operations within 1% of peak efficiency). NMFS' studies of turbine survival for yearling chinook in the Snake River produced estimates of 92.0%, 86.5%, and 92.7% at Little Goose, Lower Monumental, and Lower Granite dams in 1993, 1994, and 1995, respectively. Steelhead survival from turbine passage at Little Goose Dam in 1997 was 93.4% (Muir et al. in review).

The Biological Effects Team and NMFS[2] used the SIMPAS model to calculate juvenile passage survival rates through the dams under the proposed action (current conditions). Inputs included turbine survival rates that ranged from 90% to 93% for yearling chinook and steelhead migrants and rates that ranged from 90% to 94% for subyearling migrants (the particular rate used for each dam is listed on Tables D-1 through D-3 in Appendix D). These turbine survival estimates are based on information presented in NMFS (2000e), Marmorek et al. (1998), and Ledgerwood et al. (1990).

6.2.3.2 Juvenile Salmonid Passage Through Bypass Systems at FCRPS Projects

The FCRPS dams use two submersible fish screen designs to guide fish away from turbine intakes and into juvenile bypass systems: a standard-length submersible traveling screen (STS) and an extended-length submersible bar screen (ESBS). STSs are currently installed at Lower

[2] To facilitate completion of the ESA Section 7 consultation process, the Federal agencies formed five action teams during January 2000. The Biological Effects Team was charged with estimating the effects of current operations and potential future configurations and operations on the survival of listed juvenile outmigrants. This information was used by NMFS to analyze the listed species' biological requirements in the action area, as well as at the species level. The team included Federal biologists and engineers representing NMFS, the Corps, and BPA. NMFS' Hydro Program staff picked up where the Biological Effects Team analysis left off to complete the biological effects analysis described in this section and in Appendix D.

Monumental, Ice Harbor, John Day, and Bonneville dams. ESBSs are currently installed at Lower Granite, Little Goose, and McNary dams. The Dalles Dam does not have a mechanical screen juvenile bypass system.

Intake screens guide migrating juveniles from turbine intakes into gatewells. FGE is a measure of how efficiently intake screens guide juveniles out of turbine intakes. Higher FGE equates with higher diversion of the migrants away from turbine passage and into the bypass system. To calculate juvenile passage survival rates through the dams under the proposed action (current conditions) with the SIMPAS model, the Biological Effects Team and NMFS used FGE rates that ranged from 39% to 83% for yearling chinook, 9% to 62% for subyearling chinook migrants, and 41% to 93% for steelhead migrants. The particular fish guidance rate selected for each dam is listed in Tables D-1 through D-3 in Appendix D. These FGE rates are based on information from the 1998 FCRPS Supplemental Biological Opinion and on NMFS (2000c,e) and Marmorek et al. (1998).

Once guided into gatewells by intake screens, fish exit through orifices to a collection channel traveling the length of the powerhouse. The channel conveys fish and the orifice flow directly to the tailrace or to a dewatering facility. The dewatering facility reduces bypass system flow to approximately 30 to 40 cfs and then the fish, with the remaining water, are sent via flume to a tailrace outfall or to a holding facility for transportation. Smolt-monitoring facilities installed at projects with key bypass systems collect data for estimating species composition, fish condition, run timing, and other passage indices. PIT-tagged fish can be detected at these facilities, the time and date of passage noted, and fish diverted for further evaluation, if needed.

Design criteria for mechanical screen bypass systems are described in NMFS (1995b,c), Corps' bypass system design memoranda (Corps 1995, 1996, 1999a), the Corps' annual Fish Passage Plan (Corps 1999e), and the American Society of Civil Engineers' manual of intake design guidelines (ASCE 1995). NMFS' guidelines for locating and designing bypass outfalls are presented in NMFS (1995b).

Bypass system survival has been evaluated using recoveries of marked fish. These estimates include both direct and at least a portion of any indirect effects of bypass systems, depending on where the tagged fish are recaptured and whether (and where) any indirect losses occur. Muir et al. (1995, 1996, 1998) reported that survival through bypass systems at Snake River dams, based on PIT-tagged fish released into the collection channel, ranged from 95.4% to 99.4% for yearling chinook and from 92.9% to 98.3% for steelhead. Estimated survival was 95.3% for steelhead that passed through the entire bypass system at Little Goose Dam in 1997 (Muir et al. 1998). Ledgerwood et al. (1994) evaluated survival through the Bonneville First Powerhouse juvenile bypass system. They found that recoveries of marked (CWT) subyearling chinook in the Columbia River estuary were significantly lower for fish that passed through the bypass and tailrace than for fish released 2.5 km downstream.

To calculate juvenile passage survival rates through the dams under the proposed action (current conditions) with the SIMPAS model, the Biological Effects Team and NMFS used bypass survival rates that ranged from 90% to nearly 99% for yearling chinook, 88% to 98% for subyearling chinook, and 90% to 98% for steelhead migrants. The particular bypass survival rate used for each dam is listed on Tables D-1 through D-3 in Appendix D. These bypass survival rates are based on information presented in the NMFS (2000e), Marmorek et al. (1998), Ledgerwood et al. (1990), and Smith et al. (2000).

6.2.3.2.1 Juvenile Salmonid Passage Through Spillways and Sluiceways at FCRPS Projects. The spillway of any FCRPS dam consists of a forebay, multiple spill gates, an ogee, a stilling basin, and a tailrace. Most spillway gates are built from a radial design with a 60-foot radius and 50-foot width. The spillways at Bonneville and McNary dams have vertically operated lift gates of similar width. The number of gates per spillway varies from 8 to 10 at lower Snake River dams to 18 to 23 at lower Columbia River dams. The ogee maintains the shape of the spillway flow between the gates and the stilling basin. Most FCRPS dams are equipped with flow deflectors that help reduce the amount of dissolved gas produced at a given level of flow; these are located on the ogee sections at elevations specific to each project.

The level of spill and daily and seasonal timing currently provided for fish passage at FCRPS dams is specified in the 1998 Supplemental FCRPS Biological Opinion (see Table III-2) and in Appendix A to NMFS (2000e). Current estimates of spill effectiveness (the proportion of fish approaching a project that pass via the spillway) for FCRPS dams are listed in Tables D-1 through D-3 in Appendix D. Spill efficiency is calculated as spill effectiveness divided by the proportion of total river flow passing over the spillway during the evaluation period. Spill efficiency and effectiveness have been reviewed recently by Steig (1994), Giorgi (1996), Whitney et al. (1997), and Marmorek and Peters (1998). Estimates of spill efficiency vary by project and the values used by the Biological Effects Team and NMFS as inputs to the SIMPAS model are listed in Tables D-1 through D-3 in Appendix D. The rates are based on information in Marmorek et al. (1998), Ploskey et al. 1999, Eppard et al. 2000, Adams and Rondorf 1999, Hansel et al. (1999), and, where empirical data were not available, on NMFS' best professional judgment.

Data on juvenile spillway passage survival for FCRPS dams are summarized in NMFS (2000e, p. 64 and Table 9). To calculate juvenile passage survival rates through the dams under the proposed action (current conditions) with the SIMPAS model, the Biological Effects Team and NMFS used spillway survival rates that ranged from 90% to 100% for yearling chinook salmon and steelhead migrants and from 88% to 98% for subyearling chinook (see Tables D-1 through D-3 in Appendix D). These rates are based on information presented in NMFS (2000e), Marmorek et al. (1998), Dawley et al. (1999), Holmes (1952), and Ledgerwood et al. (1990).

In its white paper on predation, NMFS (2000f) identifies a key issue that connects these fish passage spill programs with predation at the FCRPS dams. Predator concentrations are typically highest in the immediate forebays and tailraces of dams, areas where smolts are delayed and where structures and back-eddies (refuge for predators) and disorientation make smolts particularly vulnerable. Because the effects of spill volume, spill patterns, and spill duration (e.g., 12- versus 24-hour) on forebay and tailrace survival are unknown (NMFS 2000f, p. 35), NMFS considers the effect of dam operations on smolt predation a critical uncertainty.

The NMFS' SIMPAS spreadsheet model combines turbine, bypass, and spillway survival rates with FGE, spill efficiency, and diel passage rates to estimate the survival of juvenile migrants at each FCRPS dam. Diel passage rates are the proportion of juvenile migrants passing during the day and during nighttime hours. The nighttime rates that the Biological Effects Team and NMFS used as inputs to the SIMPAS model are listed in Tables D-1 through D-3 in Appendix D. For yearling and subyearling chinook and steelhead migrants, these range from 50% to 83%, varying by dam and season (NMFS 2000f, Marmorek et al. 1998, Kuehl 1986, Biosonics 1998, Steig and Johnson 1986, Sullivan et al. 1986, and, where empirical data were not available, NMFS' best professional judgment).

6.2.3.3 Estimates of Post-Bonneville Juvenile Mortality Related to Passage Through FCRPS Under Proposed Action

Any mortality of juvenile salmonids that occurs after fish have passed Bonneville Dam can be caused by natural processes such as predation, competition, effects of ocean productivity on growth and health, and climate-induced effects on habitat quality. However, mortality can also be related to a variety of anthropogenic factors such as poor fitness of introduced hatchery stocks, effects such as degradation of rearing habitat (including the estuary and nearshore ocean) on wild stocks, harvest, and delayed effects of passage through the hydrosystem. The latter, a subject of this biological opinion, is discussed in two forms: the differential delayed mortality (D) of transported fish (compared with inriver migrants), and the delayed mortality of inriver migrants.

6.2.3.3.1 Delayed Mortality of Transported Smolts. The differential delayed mortality of transported fish is expressed as the ratio of the post-Bonneville survival of transported fish to that of nontransported fish (differential post-Bonneville survival, D). If the ratio is 1.0 or greater, then transported fish have an equal or greater post-Bonneville survival rate than nontransported fish. If the ratio is less than 1.0, the post-Bonneville survival of transported fish is lower. In the latter case, the difference is generally attributed to delayed effects of the collection and transportation processes. NMFS estimated a mean value of D for the combined 1994 through 1997 outmigrations for SR spring/summer chinook salmon and SR steelhead (NMFS 2000i) using two methods for expanding empirical estimates of inriver survival (a step necessary to estimating D; see NMFS 2000i).

The two methods were used to produce the following range of mean D-values for each species:

	Mean 1994-97 D Estimate
SR spring/summer chinook salmon	0.63 - 0.73
SR steelhead	0.52 - 0.58

Although these estimates represent the best scientific information available at this time, NMFS notes that they are based on relatively small numbers of returning adults and that large confidence intervals surround each estimate (NMFS 2000i).

Even more uncertainty exists regarding the differential post-Bonneville mortality of transported SR fall chinook salmon. Because this species has not been the subject of formal transportation studies, the scientific justification for any given estimate of D is weaker than for SR spring/summer chinook salmon or steelhead. NMFS (2000i) reviewed the range of alternative assumptions used by Peters et al. (1999) to estimate D for this species: application of returns of transported and nontransported fish PIT-tagged during the 1995 outmigration; application of transport studies from McNary Dam (i.e., based on Hanford Reach fall chinook) to SR fall chinook; and comparisons of different assumptions about D and other values in relation to the best fit of a life-cycle model to the observed recruit-per-spawner data. The estimates of D derived using these alternative methods ranged from approximately 0.05 to over 1.0. NMFS (2000i) reviewed the methods and noted that each had inherent strengths and weaknesses. For purposes of this biological opinion, NMFS considers the PIT-tag method used by PATH more consistent with methods used by NMFS to estimate spring/summer chinook and steelhead Ds than either of the other PATH approaches. Using this method, PATH estimated D = 0.24, with very wide statistical confidence limits. NMFS finds that this represents the best fall chinook D-estimate currently available and applies it as a point estimate in the analyses discussed in Section 6.3, below. Because the estimate should be viewed with caution, NMFS presents a sensitivity analysis to a range of possible D-values in Appendix A.

For purposes of the analyses described in this biological opinion, the estimated D-values described above are assumed to have occurred under the conditions of the proposed action. Empirical evidence to the contrary is lacking. The D-value for UCR spring chinook salmon transported from McNary Dam is assumed equal to that estimated for SR spring/summer chinook salmon transported from all collector projects (between 0.63 and 0.73). The D-value for UCR steelhead transported from McNary Dam is assumed equal to that estimated for SR steelhead transported from all collector projects (0.52 to 0.58). Few individuals from these ESUs would be transported under the proposed action (current operations).

6.2.3.3.2 Delayed Mortality of Nontransported Smolts. Time-series of adult returns for salmon and steelhead indicate that stocks declined throughout the Pacific Northwest starting in the late 1970s (NRC 1996). However, stocks from the Snake River appeared to decline more than lower Columbia River stocks. PATH modeling on the effects of the hydrosystem on salmonid populations indicated that direct losses through the hydrosystem alone could not account for the changes in spawner/recruit ratios observed between the 1960s and 1980s. The magnitude of this unexplained extra mortality depends on the analytical framework from which it is derived, since it is the leftover mortality or loss of productivity that is not accounted for by other predictor variables in a salmon life-cycle model. In the biological opinion modeling framework, which uses a different life-cycle model than that employed by PATH, the extra mortality is based on PATH models and is mortality that is not accounted for (or that may be incorrectly accounted for) by the following:

1. Spawner-recruitment productivity parameters

2. Estimates of direct mortality from inriver juvenile passage models

3. Estimates of additional delayed mortality of transported fish relative to inriver fish (D value)

4. A year-effect term that accounts for year-to-year changes in productivity that are common across a large group of stocks and that is intended to capture common environmental effects

PATH developed three hypotheses to explain the potential sources of the unexplained mortality: hydrosystem, ocean regime shift, and stock viability degradation (Marmorek and Peters 1998). Mechanisms by which the hydrosystem could produce extra mortality (i.e., in the form of delayed mortality of nontransported fish) include the effects of hydrosystem regulation on flow and the timing of ocean entry, the cumulative effects of stress/injury associated with bypass system or hydrosystem passage, and the effects of disease transmission and delay as fish transit bypass systems or fish ladders. Schaller at el. (1999) analyzed spawner/recruit data and contrasted productivity patterns for yearling chinook salmon stocks from the upper Columbia and Snake rivers with those from the lower Columbia River, concluding that differences in productivity between the upper and lower river stocks are primarily due to the number of dams each must pass (eight or nine versus three or fewer dams). The other two hypotheses proposed by PATH contend that the unexplained mortality is not caused by the hydrosystem and, therefore, is not delayed mortality. The ocean-regime-shift hypothesis attributes the recent low survival of salmonids to cyclical changes in ocean productivity. The stock-viability-degradation hypothesis represents the potential negative effects of hatcheries on wild stocks, including effects of diseases, inbreeding depression, etc.

Uncertainty continues over the importance of the hydrosystem as the source of extra (delayed) mortality, or whether the effect should be attributed to other factors. The rate at which mainstem projects were added to the hydrosystem is autocorrelated with changes in ocean productivity, changes in Columbia River hydrology affected by increased storage capacity in the upper Columbia and Snake river basins, reliance on hatcheries to meet production goals, habitat degradation, and other factors that came into play during the same period. Because these trends coincide but were not planned as a statistical experiment, statistical methods cannot be used to define the cause of delayed mortality.

Recent PIT-tag studies also bear on the question of extra mortality as the delayed mortality of nontransported fish. The SARs of smolts that were PIT-tagged during the 1995 migration differed according to the number of projects at which they were detected (i.e., in the bypass system). The more frequently a fish was detected, the lower the SAR. These differences cannot be explained by differences in direct passage survival rates. Although there were insufficient returns from the 1996 migration to make similar estimates, and returns from the 1997 migration did not indicate a multiple bypass effect, the pooled 1995-through-1998 data indicate that adult return rates for fish that passed one or more times through the bypass systems are lower than for fish that were never detected (NMFS 2000e). The differences are not statistically significant.

NMFS (2000e) reviewed several hypotheses to explain the results. Consistent with the delayed mortality of nontransported fish, the reduced return rate may be a result of cumulative stress or injury associated with the bypass experience. Alternatively, NMFS (2000e) pointed out that the observations may be related to 1) problems with the PIT tags used in 1995; 2) problems associated with the PIT-tag diversion systems rather than the bypasses (which would not have affected the run at large); or 3) a higher incidence of bacterial kidney disease (BKD) infection in fish moving at greater depths (i.e., fish likely to be guided into bypasses). The second of these hypotheses was tested at Lower Monumental Dam during 1999. The results indicated no difference between fish bypassed directly to the river and those passing through the juvenile fish monitoring facility (NMFS 2000e). The third alternative was tested by exposing juvenile chinook salmon infected with the bacteria that cause BKD to stressors and hypoxia, simulating potential deleterious conditions during bypass passage (Mesa et al. 2000). Infection levels and mortality were unchanged.

NMFS (2000e) reviewed the evidence for or against each hypothesis regarding delayed mortality of nontransported fish. No conclusions were drawn, and NMFS noted the need for additional research. However, to conduct the analysis described in this biological opinion, it is necessary for NMFS to assume either that no delayed mortality exists, or that some level of delayed mortality occurs, based on the best available scientific information. The choice can have a significant effect on analytical results, as demonstrated by Marmorek and Peters (1998) and Peters and Marmorek (2000).

In light of this review, and on the basis of its best professional judgment, NMFS applied a range of delayed mortality assumptions to the analyses of Snake River ESUs in this biological opinion. At the low end of the range, NMFS assumed no delayed mortality of nontransported fish and, at the high end, assumed that all extra mortality estimated by PATH was delayed mortality, caused by passage through the four Snake River dams. It is doubtful that either of these extreme estimates is correct, but they were chosen to capture the range of possible values. Several agencies and organizations that reviewed the July 27 draft biological opinion commented that NMFS should abandon the 0% delayed mortality assumption. NMFS agrees that there may be some nonzero minimum level of delayed mortality of nontransported fish. However, NMFS has no basis for defining that level. It is noteworthy that two of the three main PATH assumptions assume that this value is zero, as described above. For upper- and mid-Columbia ESUs, NMFS assumed that delayed mortality of nontransported fish might be as low as zero but would be no higher than the PATH estimates for the same species in the Snake River. For lower Columbia River ESUs, which pass no more than one FCRPS dam, NMFS assumed no delayed mortality.

6.2.4 Effects of Project Operation on Adult Salmonid Passage—General Considerations

Three specific components of adult migration through the FCRPS corridor may affect listed species: 1) delay at project fishways; 2) passage success at project structures; and 3) injuries and mortalities resulting from upstream and downstream passage through project facilities. Each component could increase prespawning mortality. For fish that reach spawning areas, indirect effects associated with passage through multiple dams can reduce fecundity and reproductive success. Unfortunately, the relationship between passage components and reproductive success is not clearly understood. In addition, a percentage of adults fail to enter project fishways and pass upstream. This could be due to a fish's inability to detect fishway entrances, or to the lack of distinguishable environmental cues inducing fish to continue upstream past the project. As a result of these indirect effects, a component of adult populations may not successfully spawn.

The hydrosystem may also have a positive effect on some aspects of the upstream migration. For example, travel time and energy expenditures of upstream migrants are lower in reservoirs than in free-flowing rivers. However, NMFS (2000e) estimates that the net effect of delay at dams, combined with faster passage through reservoirs, is a median travel time through the lower Snake River that is the same or faster with dams in place than with no dams.

Adult salmon and steelhead pass upstream through FCRPS dams by means of fishways that were installed as part of the original project construction. The fishways typically consist of an entrance gallery and ladder, a diffuser system that provides additional water at the ladder entrances (to attract fish from the tailrace), and a flow-control section at the ladder exit that maintains ladder flow over various forebay elevations. Observation areas are established in each ladder to monitor upstream progress (i.e., fish-counting stations). The ladders at Bonneville and Lower Granite dams have traps used for broodstock collection and monitoring. Migrational delays are most likely to occur at fish ladder entrances, in the collection galleries (at junctions between galleries and ladders), and when the traps are operated. Injury related to adult fish passage facilities is usually minimal. However, system failures (e.g., displacement of diffuser gratings in the entrance pools) can result in significant injury and mortality.

Adult passage information (e.g., time spent immediately downstream of the dam, success of entry into the collection channel and fishway entrances, time taken to traverse the ladder) is typically evaluated using radiotelemetry. Therefore, project passage data assess how well radio-tagged fish pass from the tailrace of a dam into and through its fish passage facilities. The behavior of radio-tagged fish is assumed to be similar to that of untagged fish, and laboratory assessments of tagged and untagged fish and several years of field evaluations support this assumption (although little information is available regarding tagging effects on subsequent reproductive success). The data do not establish a direct relationship between project passage times and reproductive success, although hypothetically, any reduction in passage time would reduce an individual's energy expenditure and improve the likelihood that it would survive to spawn. Although specific criteria are not available, obvious delays in passage may indicate a need for operational or structural modifications.

Adult radio-tagged fish are monitored with aerial and underwater antennas as they move through the tailrace and into and through the fish passage facilities. Additional information can be collected by manually tracking radio-tagged fish from a boat or plane. Project passage times are only developed for radio-tagged fish that successfully pass the dam. Although data for fish that do not pass the dam are of equal or greater value, it is very difficult to determine a causative factor for this behavior. Failure to pass a dam may be the result of a poorly designed passage facility, inadequate attraction flows, or complicated flow patterns, exacerbated by project operations. Fish that fail to pass a dam may also be destined for a downstream spawning location or may have been injured before reaching the dam (due to natural or other effects). Tagging effects or regurgitated tags, none of which are related to operation of the facilities, can also be manifested in the data set and affect the conclusions. As a result, the detection rate of radio-tagged fish as they advance upstream indicates a rate of adult loss that cannot be entirely attributed to a particular experience, such as dam passage, but must be attributed to a combination of factors. This adult loss rate, termed "unaccountable adult loss," cannot be used to isolate specific cause-and-effect relationships between passage and reproductive success. It can be used, however, to assess the general, overall success of adult salmonids migrating upstream through the Snake and Columbia river corridors and to develop an index for assessing annual improvements in passage conditions. Nevertheless, factors contributing to unaccounted losses must be partitioned so that appropriate improvements can be determined.

6.2.4.1 Effect of FCRPS Project Operation on Adult Salmonid Passage

The survival of radio-tagged spring/summer chinook salmon from Ice Harbor Dam to Lower Granite Dam was high in the 1990s, ranging from 86% (1993) to 98% (1998) for adult fish tagged in the lower Columbia River. Migration rates vary with species, year, season, and environmental conditions. In general, fish appear to move through the projects at rates similar to unimpounded reaches. Bjornn and Peery (1992) concluded that, in the Snake River before impoundment, spring/summer chinook salmon migrated from 18 to 24 km/day. In recent radio-tracking studies (1996 to 1998), spring/summer chinook salmon traveled the reach between Ice Harbor and Lower Granite dams at a median rate of 14 to 20 km/day (Bjornn et al. 1998). Further, a 1993 comparison of travel times through impounded and unimpounded Snake River reaches showed little difference in median travel time for this species (Bjornn et al. 1999a). In 1998, the median migration rates for PIT-tagged adults between Bonneville and Lower Granite dams were 38 km/day for fall chinook salmon, 27 km/day for spring/summer chinook salmon, and 14 km/day for steelhead of known Snake River origin. Steelhead migration rates vary with season and temperature (NMFS 2000e).

Adults can be delayed at dams during periods of high daytime spill (Turner et al. 1983, 1984) by increased difficulty in finding ladder attraction flows as well as fallback. Adult migration times increase as fish (re)locate the ladder and reascend the dam. Fallback rates as high as 20% have been documented for total dam fallback; a 28% fallback rate has been documented for fish exiting the Bradford Island ladder at Bonneville Dam (Bjornn et al. 1998). Mortality rates of 8% have been observed for adults falling back through spillways (Bjornn et al. 1998) and 14% to 26% for fallback through turbines (Mendel and Milks 1995).

The Biological Effects Team and NMFS used results from radiotelemetry studies to estimate minimal adult survival and unaccountable adult loss under the proposed action (current operations) for steelhead and spring/summer and fall chinook salmon passing through the FCRPS projects. Lacking telemetry study information for Snake River sockeye, the Biological Effects Team and NMFS used the survival estimate reported in the 1995 FCRPS Biological Opinion (based on 1985 to 1994 dam count analyses) and telemetry information collected in 1997 with sockeye tagged at Bonneville and monitored to Wells Dam on the upper Columbia. The current minimal survival for those Snake River species migrating through eight FCRPS dams is estimated to range from 71% for fall chinook salmon to 86% for sockeye (Table 6.1-1). The current minimal survival rates for steelhead and spring chinook salmon fall between these values. The Biological Effects Team and NMFS used these estimates of current minimal survival through eight dams to calculate the approximate per-project survival rate, assuming that the survival through each dam is similar. Current per-project minimal survival ranges from 96% for fall chinook to 98% for sockeye. These per-project minimal survival rates were then used to calculate minimal survival rates for species for which specific radiotelemetry FCRPS passage results were unavailable, such as UCR steelhead and spring chinook (Table 6.1-1). Unaccountable loss through eight dams, which range from 14% for sockeye to 29% for fall chinook, are attributable to unaccounted tributary turnoff, unreported catch, indirect effects of harvest, regurgitated tags, and dam passage (i.e., mortality during fallback through turbines).

6.2.4.1.1 Downstream Migrating Adults (Kelts). Unlike chinook salmon, steelhead may survive to spawn more than once. Before construction of most of the lower Columbia and lower Snake River dams, the proportion of repeat spawning summer steelhead was small, e.g., 3.4% (Long and Griffin 1937). A study of repeat spawners to the Clearwater River showed a 1.6% return (Whitt 1954). More recently, summer steelhead populations that do not pass through any dam or pass through only one (i.e., spawners from lower Columbia River tributaries) have approximately 7% and 3% proportions of repeat spawners, respectively (Howell et al. 1985, cited in Busby et al. 1996).

Data acquired through sampling in the Lower Granite and Little Goose dam bypass systems during the peak fallback season of April through June 2000 were used to arrive at a preliminary estimate of 16,745 steelhead kelts present in the Lower Snake River at Lower Granite Dam during the study period (Evans and Beaty abstract in Corps 2000 Annual Research Review).

The mortality of kelts passing FCRPS projects has not been estimated. For those that pass through turbines, mortality is probably similar to that estimated for upstream migrating adults that fall back through turbines. It is unlikely that many kelts survive multiple dam passage to spawn a second time.

6.2.5 Effects of Water Regulation and Impoundments on Salmonid Migration and Survival—General Considerations

One indication of historical trends in salmonid habitat alteration by hydroelectric (and multipurpose) dams is the total amount of water stored by these projects (total storage capacities). The Corps (1984) defines major hydroelectric projects as those having an active storage capacity in excess of 100,000 acre-feet (kaf), or with an installed generating capacity greater than 40 megawatts (MW). According to the Corps, there are 89 such projects in the Columbia River basin. Their combined active storage capacity is over 57.3 million acre-feet (Maf), and their combined hydrosystem generating capability is over 35.7 gigawatts. This total storage capacity represents over 40% of the Columbia River's average annual runoff volume. Many of the largest storage projects have been developed in the area of the Columbia River above Chief Joseph Dam, the current upstream limit of the range of anadromous salmonids in the Columbia River.

Because the reservoirs have greater surface areas and volumes and lower water velocities than the undammed river, changes in water temperature, dissolved oxygen levels, turbidity, water chemistry, and aquatic habitat may result. In deep reservoirs, thermal and chemical stratification is likely to occur, with potentially significant effects on the aquatic life in the reservoir and farther downstream. The downstream effects can be either beneficial or adverse, depending on the site, water quality, and size of the impoundment. Fish that reside in reservoirs are often better adapted to the characteristics of slow-moving water than salmonids, which evolved in free-flowing systems.

In addition, because all but the most buoyant types of suspended materials settle out in reservoirs, these impoundments alter suspended loads and patterns of sediment deposition downstream. Altered particulate loads may affect aquatic assemblages in the water column and patterns of deposition in downstream river reaches, the estuary, and nearshore ocean environments.

6.2.5.1 General Effects of FCRPS Hydrosystem Operations on Salmon and Steelhead

Development of multipurpose storage dams and hydroelectric projects on the mainstem Columbia and Snake rivers has greatly altered the natural runoff pattern in the basin by increasing fall and winter flows and decreasing spring and summer flows. Spring runoff is now stored in large headwater reservoirs so that it can be used to produce electricity on demand, as well as to provide benefits for flood control, irrigation, navigation, and recreation. Fourteen of the 89 basin reservoirs, both inside and outside the FCRPS, are routinely drafted in the winter and early spring to control mainstem floods and meet winter electrical loads. Changes in the pattern of runoff affect flow and temperature in the river channel as well as the character of the estuary and size of the freshwater plume in the nearshore ocean.

Dam development and reservoir storage on the mainstem Columbia and Snake rivers have reduced spring flows and increased the cross-sectional area of the river, resulting in reduced water velocities and downstream migration delays. Migrating salmon must pass up to nine dams and reservoirs on their migrations to and from the ocean. Longer travel time affects the migratory behavior of juvenile fish and increases their exposure to predatory fish and birds.

Adult salmon migrating to natal spawning grounds also are delayed at dams during high flow years, due to their difficulty in locating fish ladder attraction flows. For example, high flow and involuntary spill conditions, which can assist downstream migrants at mainstem dams, may hinder upstream fish migration by masking attraction flows to the fishway or inducing fallback. Adult fallback can cause mortality to fish passing through the turbines or can cause delay by requiring fish to find and reascend the ladder. High spills can also increase exposure to nitrogen supersaturation, which in extreme cases can result in direct or indirect (delayed) mortality. Increased migration time at several dams may have a cumulative effect, resulting in prespawning mortality of adult fish or reduced success of late spawners.

Operation of FCRPS projects has a systemwide effect on anadromous fish because of the integrated operation of the various Federal projects for power generation and flood control objectives (see below). Operational effects of FCRPS dams on salmonids include the following:

- Turbine mortality
- Migration delay, which may increase exposure to factors (such as disease) that reduce viability
- GBT and mortality
- Increased susceptibility to predation
- Bypass system and spillway mortality
- Combined effects resulting from regulated flows and temperature regimes
- Power-peaking operations resulting in stranding and dessication or exposure to bird predators

6.2.5.2 Streamflow Effects of FCRPS and Other BOR Project Operations

The FCRPS affects streamflow primarily through operations designed to produce power, control floods, and supply water for irrigation. The following sections describe the nature of power production, flood control, and water supply operations and estimates the effects of these operations on flow conditions in the mainstem Columbia and Snake rivers.

6.2.5.2.1 Electrical Generation. Each of the FCRPS projects in the lower Snake and Columbia rivers contains one or more powerhouses. The eight projects are operated in a coordinated fashion to meet current and anticipated electrical loads, both within the region and in other areas. Surplus generation is marketed by BPA. Electrical loads are typically highest from 6:00 a.m. to 10:00 p.m., are higher during weekdays than on weekends, and peak with seasonal heating and cooling demands. Operations for power production mimic demand.

The FCRPS and other power generating utilities in the Pacific Northwest are operated under the Pacific Northwest Coordination Agreement (PNCA) to meet anticipated electrical loads. The PNCA calls for annual planning, which must accommodate all the authorized purposes of the Columbia River hydro projects. It establishes processes that coordinate the use of planned U.S. - Canada Salmon Treaty storage operations with Federal and non-Federal project operations in the Northwest, and it enables the region's power producers to optimize system reliability and power production after giving priority to nonpower objectives. It recognizes project and system requirements that frequently change to serve multiple river uses. Individual project owners set the requirements for using their own reservoirs.

All PNCA parties coordinate to meet multiple-use system requirements. Power generation, which is planned under terms of the agreement, complies with these requirements. The PNCA planning process establishes day-to-day rights and obligations to exchange power, draft reservoirs, and associated transactions. The PNCA parties conduct annual planning. Each party to the agreement identifies its anticipated electrical loads, the output of its nonhydro resources, planned maintenance outages, and any existing contracts for firm energy purchases or exchanges. Each reservoir owner submits multiple-use operating requirements and constraints (flood control, irrigation, fish, wildlife protection, municipal use, and navigation) that must be incorporated into the annual plan. These requirements and constraints are analyzed to determine the firm energy load carrying capacity (FELCC) for the system as a whole and for each PNCA party individually.

The FELCC is the amount of energy each individual utility system, or the coordinated system as a whole, can produce on a firm basis during actual operations. Firm energy is produced over the region's worst water condition, called the critical period, defined as that portion of the 60-year streamflow record that would produce the least amount of power with all reservoirs drafted from full to empty. Reservoir draft limits (critical rule curve and refill curves) are established to facilitate meeting the FELCC while maintaining a high probability of refill. Reservoir operators are obligated to operate within the constraints imposed by these curves or else they incur power exchange obligations.

The effects of load-following are well outside the range of conditions that aquatic organisms might experience in a natural river. Little natural (free-flowing) habitat remains in the Columbia River downstream of Chief Joseph Dam. The reach between the head of McNary pool and Priest Rapids Dam (known as the Hanford Reach) is a notable exception. On the Columbia, the tailrace of one project flows almost immediately into the forebay of the next. Similarly, the natural river has been replaced by reservoirs in the Snake River from the head of Lower Granite Reservoir to the Snake's confluence with the Columbia.

Through careful coordination, daily peaking operations result in modest changes in reservoir water levels. However, flow velocities within the reservoirs change diurnally in a pattern similar to the daily flow fluctuations, including a lag associated with reservoir hydrodynamics. In riverine sections like the Hanford reach (with shallow margins and gravel bars), flow fluctuations can lead to entrapment and stranding of spawning adults and juveniles in rearing habitat.

6.2.5.2.2 Flood Control. Flood control is an authorized purpose at six FCRPS storage reservoirs (Albeni Falls, Dworshak, Grand Coulee, Hungry Horse, John Day, and Libby). Both Federal and non-Federal storage reservoirs in the basin, including several U.S.–Canada Salmon Treaty reservoirs, are operated in a coordinated fashion to reduce the risk of floods, both in local areas downstream of several projects (local flood control) and in the Portland, Oregon–Vancouver, Washington, urban area (system flood control). The latter function—systemwide flood control—is accomplished by drafting the major storage reservoirs during fall, winter, and early spring, providing space to protect against unusual rainfall events and to capture the spring freshet. The Corps' objective is to "operate reservoirs to reduce to non-damaging levels at all potential flood damage areas in Canada and the United States insofar as possible, and to regulate larger floods that cannot be controlled to non-damaging levels to the lowest possible level with the available storage space" (Corps 1999b).

Runoff is forecast from monthly snowpack surveys from January to May, weather forecasts, soil moisture content, and anticipated future precipitation. The estimates are used to identify flood storage requirements at each project, using predetermined storage reservation diagrams. Also termed rule curves, the diagrams anticipate the minimum amount of storage that will be required at the end of each month to reduce flood risk to an acceptable level. As such, the rule curves also define the maximum reservoir water surface elevation allowed under existing conditions and criteria.

Flood control operations can be considered in two steps: reservoir evacuation (drafting) in advance of the spring freshet (most likely flood season in the Columbia basin) and reservoir refill during the freshet and temporarily during intervening runoff events. Drafting is conducted in two periods. During September through December, several projects are drafted to meet predetermined targets (runoff forecasts are not yet available, and early drafting facilitates the deep drafts required in the wettest years before the flood/refill season). Early drafts also provide protection from fall floods and increase system generation. During January through March, drafting varies with predicted runoff and available storage space, in accordance with established storage reservation diagrams. During April through July, reservoirs are gradually refilled to provide flood protection (by reducing river flows that would otherwise occur) while reducing potential spill, generating electric power, and providing the flows that outmigrating salmon need.

6.2.5.2.3 Effects of BOR Project Operations. The proposed action includes continued operation of BOR's 19 projects in the Columbia River basin (Table 1-1), excluding those in the Snake River basin, as they are currently operated.[3] Operation and configuration of BOR's projects have both direct and indirect effects on salmon survival. Direct effects include entrainment at project diversions, attraction to unsafe habitats such as wasteways, and discharge of warm and/or contaminated water from wasteways. Indirect effects are primarily associated with changes in flow timing due to reservoir storage management activities and streamflow depletion from water withdrawals. Of these, NMFS considers streamflow changes the most pervasive, affecting flow-dependent habitat in tributaries, throughout the migration corridor, and into the estuary.

By storing and releasing water at project reservoirs and by diverting water to serve project lands, BOR project operations affect streamflow conditions downstream of each project. Except for the Hungry Horse Project, all BOR projects deplete streamflows by making water available for irrigation, providing most of the Federally authorized irrigation water in the basin. About 33 Maf are diverted from the Columbia River and its tributaries annually for private and Federal irrigation, and about 14 Maf of this total are consumed (BOR 1999a). Of the 4.1 Maf diverted at BOR projects upstream of the Columbia River's confluence with the Snake River, 2.3 Maf are consumed (BOR 2000a) (Table 6.2-1).[4] All but about 311 kaf of this 2.3 Maf depletion occurs when available storage is being managed to achieve NMFS' flow objectives (April through August).

As indicated in Section 1, this analysis focuses on BOR irrigation project effects on streamflow in the mainstem Columbia River during the juvenile salmon migration season (April through August). Where they exist, other salmon survival effects of BOR's projects (except the Columbia Basin Project and projects upstream of Chief Joseph Dam) will be further evaluated in consultations designed to supplement this biological opinion. All known effects of the Columbia Basin Project are described here and in Section 6.2.5.2.5. These effects could occur in the tributaries, the mainstem Columbia River, and the Columbia estuary. The only known effects of

[3]Because of ongoing negotiations in a general adjudication of water rights under way in Idaho, BOR could not adequately define its proposed action to facilitate consultation for its 11 irrigation projects in the Snake River basin. Since discussions are continuing, BOR has indicated that the proposed action may be different from those measures set forth in its December 21, 1999, biological assessment. Accordingly, BOR has asked to extend the consultation on these 11 projects pending a revised proposed action and analysis of effects. NMFS has agreed to extend the current consultation with regards to BOR's projects in the Snake River basin and to exclude those projects from this biological opinion. BOR anticipates providing the necessary additional information, and NMFS anticipates issuing a supplemental biological opinion on these projects before water from these projects is needed for irrigation use in the 2001 growing season.

[4]These water consumption estimates are based on crop consumption data. Actual streamflow depletions may be larger due to evaporation in project reservoirs, conveyance losses, and in the case of the Columbia Basin Project, losses from an extensive network of secondary reservoirs and wetlands. The estimates also assume that diverted water that is not consumed by crops returns to the river during the months in which the diversions occur. This is not always true. Actual streamflow depletion effects of BOR-supplied irrigation during the juvenile salmon outmigration range between the total amount of diversions and storage change (11.4 Maf) and total crop consumption (5.6 Maf).

the projects above Chief Joseph Dam on listed salmon and steelhead result from the cumulative hydrologic effects of their operations on streamflows in the Columbia River downstream of Chief Joseph Dam.

Estimating the hydrologic effects requires defining the flow conditions that would occur if BOR's projects did not exist or were operated with constant storage volumes and without diversion. For purposes of this biological opinion, NMFS defines the "constant storage" environmental baseline as the estimated flows under current operations at a given point plus the current levels of BOR-caused flow changes upstream of that point, less any return flows. Flow change includes reservoir operations and can result in increased streamflows when reservoir drafting exceeds crop consumption rates. The principal sources for these data are estimated mean monthly water use for recent years, provided by BOR (2000a,b), and the estimated hydrologic effects of operating all projects in the basin as proposed over a 50-year record (1929 through 1978), provided by BPA (2000a).

Table 6.2-1. Estimated monthly average crop water consumption (acre-feet of water consumed) at BOR's irrigation projects in the Columbia River basin.

Project	March	April	May	June	July	August	September	October	Project Totals
Columbia Basin Project	53,708	237,659	247,423	228,452	266,389	213,787	141,075	76,479	1,464,972
Yakima Project		13,608	119,524	190,512	217,955	119,524	27,216	7,031	695,370
Green Spots [1]		2,457	17,139	34,400	50,781	29,834	5,529	635	140,775
Upper Basin Totals	53,708	253,724	384,086	453,364	535,125	363,145	173,820	84,145	2,301,117
Umatilla Project			11,456	16,468	21,480	16,468	5,728		71,600
Deschutes River			40,715	69,797	93,062	78,521	11,633		293,728
The Dalles		504	1,890	2,520	3,276	2,646	1,512	252	12,600
Willamette River		297	1,782	9,207	13,662	3,861	891	297	29,997
Basin Totals	53,708	254,525	439,929	551,356	666,605	464,641	193,584	84,694	2,709,042

Source: BOR 2000(a,b).
[1] Several small projects in the upper Columbia River basin (Bitteroot, Missoula Valley, Frenchtown, Dalton Gardens, Avondale, Rathdrum Prairie, Spokane Valley, Chief Joseph, and Okanogan).

Hydrologic effects are not biological effects. Streamflow conditions in the migration corridor have been found to affect juvenile salmon survival (NMFS 2000h), however, and NMFS has established flow rates at several sites that serve as water management objectives to protect outmigrating juvenile salmon (NMFS 1995a, NMFS 1998). This assessment focuses on how BOR-based flow depletions affect the probability that the flow objectives can be achieved.

Several commenters noted that even if BOR discontinued delivering water for irrigation, it is unlikely that all the released water would remain instream. Private diversions would capture some fraction of the water, perhaps most. Therefore, although the following analysis attributes substantial streamflow depletion effects to BOR project operations, it is not clear that BOR could, with any reasonable certainty, avoid these effects.

Based on recent water use information (BOR 2000a,b), the combined effects on Columbia River flows at Priest Rapids and McNary dams of all the BOR projects considered in this opinion are shown in Table 6.2-2.

Table 6.2-2. Estimated monthly streamflow depletions (cfs) at Priest Rapids and McNary dams caused by BOR's 19 irrigation projects in the Columbia River basin.

	April	May	June	July	August
Priest Rapids	4,042	4,310	4,425	5,167	3,969
McNary	6,654	8,604	7,647	6,056	1,681

Source: BOR 2000a,b.

In the following analysis (Tables 6.2-3 and 6.2-4), the frequency with which mean monthly streamflows for each month during the juvenile migration season (April through August) over the 50-year simulation (BPA 2000a) would meet the applicable objective under the proposed action (BPA 2000a) is compared with objective attainment without BOR-based irrigation. NMFS assumes that the estimated monthly streamflow depletions attributable to BOR in recent years (BOR 2000a,b) approximates the quantity of BOR depletions for all years. This assumption is required because whereas total streamflow depletions have been estimated on a monthly basis for the entire period of record (BPA 1993, BOR 1999b), no previous study has isolated the effects of BOR-based irrigation depletions from total irrigation depletions.

Table 6.2-3. Percent of years that simulated mean monthly flows at Priest Rapids Dam from 1929 through 1978 (50-year record) would meet NMFS' flow objectives without BOR-caused flow changes and under current operations (proposed action). [1]

Month (objective)	Without BOR-caused Flow Changes	Current Operations	BOR-caused Nonattainment
April (135 kcfs)	62 %	56 %	6 %
May (135 kcfs)	90 %	86 %	4 %
June (135 kcfs)	86 %	78 %	8 %

Source: NMFS analyses, based on BOR (2000a,b) and BPA base case HYDROSIM run 00FSH30 (BPA 2000a).

[1] The seasonal flow objective is considered met if monthly average flows are within 1,000 cfs of the objective.

Table 6.2-4. Percent of years that simulated mean monthly flows at McNary Dam from 1929 through 1978 (50-year record) would meet NMFS' flow objectives [1] without BOR-caused flow changes and under current operations (proposed action).[1]

Month (objective)	Without BOR-caused Flow Changes	Current Operations	BOR-caused Nonattainment
April (220-260 kcfs)	60 %	48 %	12 %
May (220-260 kcfs)	74 %	64 %	10 %
June (220-260 kcfs)	58 %	50 %	8 %
July (200 kcfs)	52 %	48 %	4 %
August (200 kcfs)	10 %	8 %	2 %

Source: NMFS analyses, based on BOR (2000a,b) and BPA base case HYDROSIM run 00FSH30 (BPA 2000a).
[1] The seasonal flow objective is considered met if monthly average flows are within 1,000 cfs of the objective.

As illustrated above, operation of BOR's reservoirs and consumption of delivered water on project lands reduces the frequency with which the flow objectives can be achieved, particularly during the spring. The spring effects include those of reservoir refill, as well as crop consumption. Reservoir refill effects are at least partially attributable to flood control operations that cannot easily be isolated from storage needed because of previous water deliveries. Irrigation-caused streamflow depletions during the summer are moderated by reservoir releases. It is, therefore, apparent that BOR's 19 projects adversely affect flow and flow-dependent salmon survival in the Columbia River primarily in April, May, and June.

Beyond these flow-depletion effects, there are other operational effects on the ability meet the flow objectives. For example, BOR operates Lake Roosevelt (Grand Coulee) to be at or above elevation 1,240 by May 1 to supply irrigation water to clients in the Columbia Basin Project. Under this operation, Grand Coulee can store water while downstream flow objectives are not being met.

These projects also have hydrologic effects outside the juvenile salmon migration/irrigation season (September through March). Depending on storage conditions and water supply forecasts, BOR may evacuate project reservoirs to provide flood storage or store incoming water to improve the likelihood of meeting subsequent irrigation demands. Those activities affect fish in the river at the time (e.g., lower Columbia River chum) and influence the reservoir storage that would have to be refilled during the spring freshet, thereby affecting subsequent juvenile migrants. The effects of storage operations during the juvenile migration season are reasonably captured in the water-use analysis presented above. The effects of BOR reservoir operations from September through March are considered in the broader systemwide context of reservoir operations, discussed in Section 6.2.5.2.4 below.

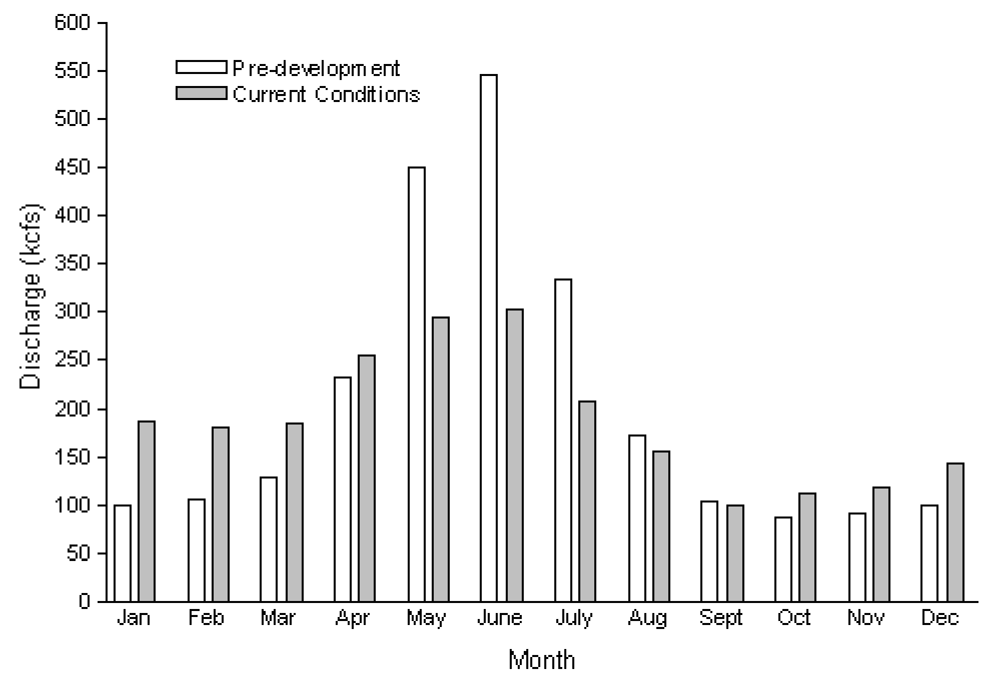
6.2.5.2.4 Cumulative Hydrologic Effects. By providing a storage capacity of almost 40% of the average annual runoff of the Columbia River above Bonneville Dam and operating to meet electrical generation, flood control, and irrigation demands, reservoir operations affect streamflow conditions in the river (Figure 6.2-1). The spring freshet (May through July) has been greatly reduced, affecting turbidity and sediment transport, estuary conditions, and the extent and characteristics of the Columbia River plume in the Pacific Ocean. Under the proposed action (current operations), mean monthly flows at Bonneville Dam in August and September mimic natural conditions. During October through March, current operations generally augment natural flows, potentially benefitting fall spawners in the Ives Island area below Bonneville Dam. Current mean monthly flows during April again mimic natural conditions. Even in months when current mean flows are similar to natural conditions, the range of weekly, daily, and hourly fluctuations due to reservoir operations for electrical load following greatly exceed what would be expected under natural conditions. Further, near-natural streamflows do not overcome the effects on salmon survival presented by the conversion of much of the river from free-flowing to a series of impoundments.

Nearly 71% of the 47 Maf of active storage capacity in the Columbia River basin is above Chief Joseph Dam (Corps 1991, NWPPC 1987), about 20.4 Maf of which is located in Canada. Therefore, most of the change in the natural shape of the hydrograph in the lower Columbia River is due to streamflow regulation in the upper basin, a substantial portion of which occurs in Canada and is outside the scope of this consultation. Also, non-Federal water developments (principally irrigation) deplete Columbia River flows by about 7 Maf annually. While Federal reservoir operations appear to be responsible for about half the total change in streamflows at Bonneville Dam depicted in Figure 6.2-1, these hydrologic effects have implications for salmon survival through the FCRPS and downstream of it.

6.2.5.2.5 Additional Effects of Columbia Basin Project. The Columbia Basin Project is BOR’s largest irrigation project in the upper Columbia River basin (above McNary Dam), diverting 2.7 Maf of water to irrigate 672,000 acres of land (BOR 2000a). Project lands extend from Billy Clapp Lake, about 40 miles south of Grand Coulee Dam, to the edges of the Pasco and Richland, Washington, metropolitan area. The continued operation of the Columbia Basin Project may affect listed salmon and steelhead in ways other than those defined by the flow-depletion analysis above.

<u>Water Quality</u>. Columbia Basin Project wasteways deliver irrigation waste water to several locations in the Columbia River downstream from Rock Island Dam. The BOR estimates that the total combined capacity of these wasteways to be less than 700 cfs (BOR 2000b). Temperatures of return flows occasionally range up to 90°F (32°C) (BOR 2000c). Irrigation return flows may also contain high concentrations of plant nutrients (nitrogen and phosphorus) and pesticide and herbicide residues. The effects of such pollution in the Columbia River is probably small, given the river’s dilution capacity (wasteway capacity is about 0.4% of average river flows). Further, water use in the Columbia Basin Project is increasingly efficient (Montgomery Water Group 1997). That is, deliveries to farmland are approaching the amount of water required by crops. Therefore, less water is wasted, and less wastewater and pollutants return to the river in project wasteways. NMFS is concerned, however, that even small

Figure 6.2-1. Simulated mean monthly discharge at Bonneville Dam before development and under current project configuration and operations. Source: BOR (1999b).



Note: Data were developed by simulating streamflow s under the alternative conditions over the 50-year period from September 1929 through October 1978. Current conditions include about 7 Maf of private-irrigation-caused streamflow depletions and Canadian reservoir operations not associated with the proposed action.

concentrations of some agricultural chemicals can adversely affect the aquatic community in general and salmon in particular (Scholz et al. 2000, Waring and Moore 1997).

Adult Attraction to Project Wasteways. Spawning adult chinook salmon have been observed in the lower portions of some of the Columbia Basin Project wasteways. Given the poor water quality in these wasteways, it is likely that spawning success is low to nonexistent. Spawning fish in this area are primarily unlisted upriver bright Columbia River fall chinook salmon. NMFS is not aware of any information on whether these wasteways attract listed fish.

Entrainment at Unscreened Diversion Pumps. The Columbia Basin Project owns and operates two pump plants (Burbank No. 2 and Burbank No. 3) in Lake Wallula (McNary pool) that are not currently screened. The intakes may attract and entrain rearing juvenile salmonids.

6.2.5.3 Effects of Water Regulation and Impoundments on Salmonid Migration and Survival

Most of the information in this section is taken from the NMFS white paper on flow, travel time, and survival (NMFS 2000h).

Hydroelectric system storage and regulation reduce river flows significantly during the spring and early summer months, when juvenile salmon and steelhead migrate downstream to the ocean (Figure 6.2-1). Reservoirs created by dams have increased the total cross-sectional area of the river, decreasing water velocity and turbidity. These conditions have led to increased travel time for migrating smolts and subjected them to greater exposure to predators and other factors of mortality (Raymond 1979, 1988; Williams et al. (in review). Moreover, the change from free-flowing river to a series of reservoirs has substantially modified the river's thermal regime. The large mass of stored water (approximately 48 Maf) has created thermal inertia, making the river slower to cool in the fall and slower to warm in the spring, thus moderating temperature extremes. Through a variety of mechanisms, these flow-related environmental changes have affected the timing of saltwater entry for juvenile migrants. Fall chinook salmon from the Snake River basin are particularly susceptible to changes in the thermal regime as they spawn and rear in the mainstem river. Further, delays in their migration due to slack water impoundments place these juvenile migrants in reservoirs during periods when water temperatures approach chinook salmon's thermal tolerance.

Flow can also affect levels of spill at dams which affects smolt travel time and survival. Spill can be forced (flow exceeds hydraulic capacity of the project) or voluntary. Voluntary spill has been used extensively since 1995 to reduce the proportion of smolts passing through turbines as prescribed in the 1995 FCRPS Biological Opinion (NMFS 1995a). Use of spill increases survival by passing greater numbers of smolts over the spillway, the route of passage with the highest survival. Spill can also reduce smolt travel time by reducing delay in forebays.

Spring migrants (spring/summer chinook salmon and steelhead) and summer migrants (fall chinook salmon) have distinct life histories and migrate downstream during separate periods. Thus, flow augmentation will have different effects on those classes of salmonids.

Spring migrants actively move through the hydrosystem as yearlings (or older). NMFS has not detected a relationship between flow and survival in the Lower Granite to McNary reach (NMFS 2000h). However, due to data limitations, these analyses did not examine the relationship through the reservoirs below McNary Dam and thus do not fully address potential flow effects. For example, predation by the northern pikeminnow is considerably higher in lower Columbia River reservoirs and the free-flowing river below Bonneville Dam than in the Snake River (Ward et al. 1995). NMFS (2000h) demonstrated, through its own analyses and a review of other studies, a strong and consistent inverse relationship between travel time and flow for spring migrants. Thus, by decreasing the residence time of smolts in the lower river, higher spring flows may reduce exposure to predators. This hypothesis has yet to be tested, but the existence of survival benefits from increased flow expressed outside the lower Snake River study reaches is supported by relationships between SARs or recruits-per-spawner and seasonal flow (NMFS 2000h).

A significant negative relationship between smolt travel time through the Snake River and subsequent return of adults (expressed as SARs) has been described for wild spring/summer chinook salmon from Marsh Creek, Idaho, for the years 1960 to 1987 (Petrosky 1992). That is, fewer adults return from years when the juvenile migration takes longer because of low stream flows than during high-flow years when the juveniles move faster. A significant relationship was observed between estimates of 1964 to 1984 SARs of all wild SR spring/summer chinook stocks (Raymond 1988) and estimates of water particle travel time during outmigrations. Smolt travel time is fairly well predicted by water particle travel time. Last, an analysis of an adult spring/summer chinook wild stock returning to the Imnaha River (tributary of Snake River) indicates that SARs are correlated with smolt travel time (Petrosky and Schaller 1992). To summarize, several studies indicate a relationship between river conditions when juveniles outmigrated and the rate at which adults returned from those juvenile year classes. Years of higher river flow produced higher rates of adult returns than low-water years.

A limitation of survival estimates made by using PIT-tags is that they measure only direct survival through part of the hydrosystem. Conditions smolts experience during migration are reflected in the estimates of smolt survival, but the indirect effects, or delayed mortality (mortality caused by passage experience that occurs downstream from PIT-tag detection sites), are not. Slower travel times could result in greater depletion of energetic reserves, reversal of smoltification characteristics, and greater exposure to disease. These factors could lead to delayed mortality not captured in the existing juvenile smolt survival studies.

SR fall chinook salmon begin downstream migration in the late spring or early summer as subyearlings. Downstream migration is protracted over several months and is accompanied by rearing. This complex life history makes interpreting data more difficult compared with spring migrants. NMFS (2000h) concluded that highly significant relationships existed between survival from release points in the Snake River to Lower Granite Dam and the factors of flow, river temperature, and turbidity for SR fall chinook salmon. Also, survival decreased markedly from early to late release dates. Because environmental variables were highly correlated, determining the most important factor for subyearling fall chinook salmon survival is not possible. The inconsistent relationships between survival from Lower Granite Dam to Lower Monumental Dam and flow, river temperature, and turbidity from year to year (NMFS 2000h), create uncertainty in the fall chinook analysis. However, releases of cold water in the summer from Dworshak Dam on the North Fork of the Clearwater River not only can help reduce elevated water temperatures, but at the same time can augment flow during the summer when juvenile SR fall chinook migrate.

River flow, water temperature, and turbidity can affect subyearling fall chinook survival in a number of ways. Fish that migrate under lower flows later in the season may be more susceptible to disorientation, reversal of smoltification, disease (Park 1969, Raymond 1988, Berggren and Filardo 1993), and a decreased tendency to migrate under conditions of low turbidity (Steel 1999). Thus, they may experience passage delays. Although the evidence for these effects is inconclusive, it indicates a potential adverse effect of the proposed action in the form of migration delays. In addition, operations at dams change under lower flows (e.g., less spill, greater diel-flow fluctuations) in ways that can decrease fish survival. Warmer water for late-season migrants leads to increased metabolic demands of predators (Curet 1993, Vigg and Burley 1991, Vigg et al. 1991) and thus to increased predation rates. The FGE of turbine intake screens is also reduced in warmer water, resulting in more fish passing through turbines (Krcma et al. 1985), which may cause decreased survival. Vulnerability to sight-feeding predators also increases as turbidity decreases (Zaret 1979) by increasing predator reactive distance and encounter rates (Vinyard and O'Brien 1976, Shively et al. 1991). Higher turbidity reduces predation rates on juvenile salmonids by providing protective cover during rearing (Simenstad et al. 1982, Gregory 1993, Gregory and Levings 1998).

Research since 1995 suggests that the spring flow objectives in the Action Agencies' proposed action for the Snake and Columbia rivers are reasonable. These flows do not mimic historical (predevelopment) streamflows, nor do they entirely overcome the migration delay imposed by the hydrosystem's dams and impoundments. However, the juvenile spring/summer chinook salmon that migrate downstream through the system have had, in recent years, direct survival rates that approach levels measured in the 1960s. This does not imply that smolt survival levels are high enough to ensure recovery for the species, nor does it suggest that flow management is the primary cause of this improvement. Rather, it suggests that flow management, in conjunction with all other fish protection measures, has had a beneficial effect on smolt survival.

Evidence for a survival benefit to fall chinook salmon from flow management is supported by research results. Data sets consistently demonstrate strong relationships between flow and survival and between temperature and survival (NMFS 2000h). Providing suitable environmental conditions would probably yield substantial survival benefits. The data indicate that the benefits of additional flow in the Snake River continue at flows well above those recently observed during a wetter-than-average hydrologic condition that included the use of stored water to augment flows (but below that observed in 1997, when survival was lower).

The likelihood of meeting the flow objectives through the Action Agencies' proposed action is summarized in Table 6.2-5.

6.2.5.3.1 Water Regulation Affects Spawning and Rearing Areas. Fall chinook salmon are known to spawn in the tailraces of Lower Granite, Little Goose, and Ice Harbor dams. Dauble et al. (1999), conducting spawner surveys using underwater video techniques, found a few redds (<20) per year of study (1993 through 1997). Although within-site fidelity appeared high, the frequency of use of known tailrace spawning areas varied. In addition, the importance of these areas to the viability of the ESU and the effects of FCRPS flow management on habitat use are unknown.

Table 6.2-5. Percent of year flows at Lower Granite, Priest Rapids, McNary, and Bonneville dams are expected to meet or exceed specified flow objectives under base case, based on 50-year simulation (1929 through 1978).

Period	Project			
	Lower Granite	Priest Rapids	McNary	Bonneville
January	N/A	N/A	N/A	88
February	N/A	N/A	N/A	78
March	N/A	N/A	N/A	78
April	38	56	48	N/A
May	60	86	64	N/A
June	68	78	50	N/A
July	40	N/A	48	N/A
August	0	N/A	8	N/A
September	N/A	N/A	N/A	8
October	N/A	N/A	N/A	20
November	N/A	N/A	N/A	74
December	N/A	N/A	N/A	90

Source: BPA 2000a. Flow objectives are Lower Granite Dam – 85 to 100 kcfs (spring) and 50 to 55 kcfs (summer); Priest Rapids – 135 kcfs (spring); McNary Dam – 220 to 260 kcfs (spring), 200 kcfs (summer); Bonneville Dam – 125 kcfs (November through March). Probability of flows exceeding 125 kcfs at Bonneville Dam during September or October are also shown, although there is no flow objective during those months under the proposed action. N/A = not applicable.

Most subyearling SR fall chinook salmon rear in the free-flowing Snake River above Lower Granite Reservoir. Connor et al. (1999) reported that these fish become pelagic-oriented once they enter the reservoir. As described above (Section 6.2.5.3), flow management operations that affect travel time, water temperature, and turbidity may affect the growth and survival of these subyearlings in a number of ways, including relative vulnerability to predation. However, there is no evidence that food resources in the pelagic zone would be adversely affected under the proposed action.

A relatively small proportion the subyearling population in the lower Snake River rear in the lower Snake River reservoirs—fry that are swept downstream from spawning areas in the lower Grande Ronde and Clearwater rivers and the mainstem Snake River below Hells Canyon Dam, and individuals spawned in the tailraces of Lower Granite and Little Goose dams. Curet (1993) reported that subyearlings were distributed primarily over sand substrate along the shoreline of Lower Granite and Little Goose reservoirs during their early rearing period, becoming pelagic-oriented when shoreline temperatures exceeded 64° to 68°F (18° to 20°C). Littoral zone food resources could be adversely affected if load-following operations periodically dewatered the substrate. However, the 1995 RPA required the Corps to operate the lower Snake pools within 1 foot of minimum operating pool, minimizing the disruption of nearshore habitat.

Hydrosystem operations also influence ecological conditions (flow, water depth) of habitat necessary for spawning, incubation, and rearing in the mainstem area (Ives Island) below Bonneville Dam. Flow management helps maintain immigration corridors between the mainstem and tributaries used for spawning by chum salmon, as well as emigration corridors for smolts. Average daily flows and flow fluctuations can affect the areal extent of available spawning habitat, cover or dewater redds, and strand juveniles and adult salmon.

Both LCR chinook salmon and CR chum salmon have been observed spawning in the Ives Island area below Bonneville Dam. LCR chinook salmon, tule-type fish that are distinguished from upriver or lower river brights by their body color (brownish tinge) and shape as well as early run timing, were observed there for the first time during October 1999 (Hymer 1999b). Field biologists reported a peak count of 45 redds on October 19th (ODFW and WDFW 1999). CR chum salmon were first observed in the Ives Island area during 1967 (ODFW, WDFW, and USFWS 1999). Targeted censuses began in 1998, when the species was proposed for listing. Both the hydraulic connection between the backwater area that separates Ives and Pierce islands (and the mainstem Columbia River) from the Washington shoreline and the areal extent of submerged spawning habitat are strongly affected by FCRPS flow management and tides. According to USFWS, ODFW, and WDFW field biologists, a Bonneville outflow of at least 125 kcfs is needed to create and sustain the hydraulic connection, with a higher flow needed to counteract any temporary drop in river elevation (e.g., during the lower low of a spring-tide cycle) (FPAC 1999). However, before construction of the Bonneville Second Powerhouse, flows as low as 90 kcfs may have been sufficient to maintain the connection (Corps 2000a). The slough that separated Hamilton Island from the Washington shoreline was bisected by a dike and backfilled with materials excavated from the construction site for Powerhouse II beginning in the mid-1970s (Harza 2000).

Although chum salmon redds can be superimposed in pristine systems, this condition may indicate that the carrying capacity of spawning habitat is exceeded (Burner 1951). Keeley et al. (1996) found that the number of migrating fry per m^2 in side channels to tributary streams reached a maximum when female density reached 1 per m^2. The Ives Island spawning area is essentially a side channel to the Columbia River. Preliminary results from a piezometer study show that it may share an important habitat characteristic with smaller side channels used by this species, upwelling through at least a portion of the available gravel (Geist 2000). Thus, flow management operations that restrict the areal extent of habitat in the Ives Island area, either by limiting access to potential habitat or by degrading habitat quality through fluctuating flows, are also likely to affect carrying capacity. The specifics of these functional relationships (i.e., effects of flow levels on the carrying capacity of spawning habitat in the Ives Island area) are the subject of ongoing research.

Chum salmon spawn in the lower Columbia River during late October through December, typically after local precipitation begins and baseflows increase in the mainstem. At present, access to chum salmon spawning habitat in Hamilton Creek and its tributary, Spring Channel, (and possibly to Hardy Creek, Hymer 1999a) is also maintained by FCRPS flows greater than 125 kcfs. Flows at this level are more likely to occur during November and December than before mid-October. However, as stated above, access may now depend on higher mainstem flows than before the Corps bisected and backfilled Hamilton Slough.

Flow through the Ives Island area is important not just during the fall spawning period but also through incubation, rearing, and emergence. Salmon sac-fry larvae are particularly vulnerable to GBT.[5] Operations such as spill for debris removal, gas generation/abatement testing, or spill for juvenile fish passage (e.g., the March release of hatchery smolts from Spring Creek fish hatchery) can create TDG concentrations high enough to kill yolk sac fry. However, mortality can be prevented by providing flows that create a compensation depth over the redds, reducing the effective TDG concentration to 105% of saturation or less.[6]

Seining data collected by the Oregon and Washington departments of fish and wildlife show that the body size (fork length) of subyearling chinook salmon captured in the Ives Island area during winter/spring 1999 and 2000 increased progressively during the period January through July (USFWS 2000b). Because tule fall chinook salmon spawned in this area only during fall 1999, most of these observations pertain to Ives Island brights (UCR summer/fall-run chinook salmon). However, it is likely that tule fall chinook also rear in the Ives Island area before emigration. Emigrating smolts and any juvenile chinook that rear in the area are subject to stranding and death due to dessication or bird predation under some Bonneville operations. In contrast, the seining data show that CR chum salmon leave the area soon after emergence (USFWS 2000).

Juvenile fall chinook salmon emerging from the Ives Island area are likely to rear in the mainstem lower Columbia River. Juvenile chinook salmon collected by beach seine at eight sites between the mouth of the Willamette River and the estuary appeared to grow in total length between April and July 1993 (Hinton and Emmett 1994). This statement is based on the shift in the mode of the length frequency distribution for fish captured each month.

6.2.5.3.2 Food Resources and Physiological Status. The hydrosystem has changed the juvenile salmonid migration corridor from a free-flowing river to a series of run-of-the-river impoundments. There are few empirical data on the relationship between FCRPS operations, food supply, diet, growth, and the physiological processes that control growth. NMFS is uncertain whether yearling chinook migrants have a biological requirement for food in the juvenile migration corridor or, if food is needed, whether the abundance or composition of the

[5] Once the yolk is fully absorbed and the body cavity has "buttoned up," fry are relatively tolerant to high TDG concentrations.

[6] Depth compensation is equal to a 10% reduction in TDG for each meter of water depth (Weitkamp and Katz 1980). For example, if TDG measured in the water over the shallowest redd is 115%, there must be at least 1 m of water covering the redds to give an effective TDG of 105% at the redd level.

prey assemblage is adversely modified by FCRPS operations. However, subyearling SR fall chinook grow and thus have a biological requirement for food in the juvenile migration corridor. As described in the preceding section, subyearling chinook salmon are primarily pelagic-oriented once they reach the head of Lower Granite Reservoir, but a small proportion of the run occupies shallow, sandy areas. Food resources in the pelagic zone of mainstem reservoirs are different from those in free-flowing reaches (e.g., terrestrial insects and zooplankton predominate in reservoirs versus aquatic insects in the free-flowing river). NMFS is uncertain, however, whether this change in prey assemblage adversely affects biological requirements for food during the juvenile migration. Similarly, water-level fluctuations associated with reservoir operations may affect the life cycles of invertebrate prey, but the existence of this effect in the Snake and Columbia river reservoirs downstream, and the potential implications for SR fall chinook subyearling migrants, are hypothetical at this time.

Although physiological processes in Pacific salmon have received a great deal of attention (Groot et al. 1995), studies have focused primarily on fish reared in production or experimental hatcheries. Smolting is a critical process for cultured fish; fish released from hatcheries as smolts are more likely to show directed migration to the ocean (Zaugg 1981, 1989; Muir et al. 1994). McKenzie et al. (1983, 1984) demonstrated that higher downstream survival of yearling hatchery fish was associated with higher percent body lipid at release. However, little is known of the endocrine and physiological status of naturally reared salmon. In a recent study in the Yakima River using wild yearling chinook salmon, Beckman et al. (2000) observed low lipid and glycogen levels in fish that were only one-third through their migration. This suggests that additional energy to support migration may come from food captured during the migration or from stored protein. If so, the causal mechanisms that lead to a high metabolic rate and catabolic status of smolts are unclear. Moreover, NMFS cannot assign effects on the physiological status of active migrants to specific operations, such as alteration of the hydrograph or flow fluctuations.

6.2.6 Effects of Project Operations on Water Quality

The operation and configuration of the FCRPS, as well as other non-Federal projects on the Columbia River, have two primary effects on water-quality-related salmon survival: dissolved gas supersaturation, and temperature.

6.2.6.1 Total Dissolved Gas

TDG is generated when water is spilled at dams. Falling water entrains volumes of air and carries the air into the depths of the stilling basin. Stilling basins are designed to dissipate energy and are often 50 to 60 feet deep. Hydrostatic pressure at depth in the basin forces the entrained gases into solution, causing supersaturation. Supersaturated gases in river water can off-gas at any air/water interface, e.g., the river surface, wave action on the surface, or air bubbles from rapids and riffles. TDG conditions often persist for many miles below spilling dams, however.

Water highly supersaturated with TDG (greater than 110% saturation) can produce a hazardous condition for aquatic organisms. Fish relying on dissolved oxygen for their life processes become equilibrated with the gaseous state of the river. Gas is absorbed into the bloodstream of fish during respiration. Supersaturated gases in fish tissues tend to pass from the dissolved state to the gaseous phase as internal bubbles or blisters. This condition is called GBT and can be debilitating and fatal to the afflicted organism, including upstream and downstream migrating salmonids (Ebel and Raymond 1976). Susceptibility to GBT is highest near the water surface, because the reduced hydrostatic pressure allows the gas to come out of solution.

Columbia River fisheries managers and the owner-operators of the hydroelectric projects recognized the TDG effects of spill and its adverse effects on salmon survival in the early 1960s. They began seeking ways to prevent gas from being driven into solution or to augment ways of getting gas out of solution once it had been generated.

The spillway deflector, or “flip-lip,” was one of the early structural mechanisms developed for this purpose. The intent of the deflector is to control the plunging water and prevent it from carrying entrained air deep into the stilling basin. When properly built, installed, and operated, the flip-lip causes the spilled water to be deflected from its downward path and be jetted out in a horizontal, or “skimming” flow. Thus deflectors reduce the amount of TDG in the tailrace within a given range of spill volumes. In years with large spring runoff volumes, the hydraulic capacity of the FCRPS projects and the design range of the spill deflectors may be exceeded. When that occurs, forced involuntary spill results, and deflector gas abatement performance can diminish. The TDG levels generated frequently exceed the biological opinion gas cap of 120% TDG, and the incidence and severity of GBT may increase.

Deflectors have been constructed and operated on the mainstem projects since the early 1970s. Recent deflectors have incorporated improved engineering factors based on lessons learned from earlier deflector design and operation, near-field testing of TDG levels, and consideration of performance-enhancing requirements. Nearly all Columbia/Snake River projects now have deflectors (Table 6.2-6). Gas-abatement measures installed at a facility upstream can have a beneficial incremental effect on TDG levels beyond the next project downstream. Moreover, cumulative benefits can result from implementing multiple gas-abatement actions at multiple dams.

A number of other gas-abatement alternatives were identified in the dissolved gas abatement study (DGAS), mandated by the 1995 FCRPS Biological Opinion and conducted by the Corps. This comprehensive, multiyear study included investigations of raised stilling basins (to prevent aeration plunging to supersaturation depths), raised tailraces (to reduce channel depths downstream of stilling basins), side-channel spillways, submerged discharge tunnels (to reduce air entrainment at the intake), and other concepts. They were found to have potential for injuring fish at an excessive rate, or creating structural problems. DGAS has not recommended further investigation of these alternatives.

Table 6.2-6. FCRPS projects with installed flip-lips, number of spillway bays, and bays with flip-lips.

Project	Total Number of Spillway Bays	Number of Spillway Bays with Deflectors
Lower Granite	8	8
Little Goose	8	6 (Bays 2-7)
Lower Monumental	8	6 (Bays 2-7)
Ice Harbor	10	10
McNary	22	18 (Bays 3-20)
John Day	20	18 (Bays 2-19)
The Dalles	23	None
Bonneville	18	13 (Bays 4-15, 18)

6.2.6.1.1 Risk Assessment of Allowing TDG to 120% of Saturation. Spilling waters at the projects is the most benign way to move nontransported juvenile downstream migrants past the dams. Spilling large volumes of water sweeps the fish in those waters over the dam and avoids passage through the turbines. The TDG generated by this strategy can exceed current water quality standards (110% TDG standard set by EPA, the affected states, and the Colville Confederated Tribes). As a result, the Federal government has to seek temporary variances of those standards before spilling water to benefit juvenile salmon.

In 1995, the region's fishery agencies and the Indian Tribes published the "Spill and 1995 Risk Management" report (WDFW, ODFW, IDFG, and CRITFC 1995). The assessment considered the benefits of spill to increase juvenile fish passage, the risks associated with spill-generated gas, and the survival of juveniles through other routes of passage. The conclusion of that report was that juvenile mortality associated with turbine passage exceeded that due to TDG from spill until the TDG exceeded 120 to 125%. Recognizing the inherent risk in the application of this conclusion to river operations, the agencies and Tribes urged implementation of an extensive physical and biological monitoring program to track the effects of the spill program. Appendix E contains an updated risk assessment for the spill program described in the 2000 FCRPS Biological Opinion and reviews the results of 5 years of the recommended monitoring program. The update provides a basis for evaluating the options considered in developing the 2000 FCRPS Biological Opinion.

The biological monitoring program has recorded the effects of the biological opinion spill program. The overall number of fish affected with GBT signs observed over the years has proven to be lower than originally assumed when the 1995 FCRPS Biological Opinion was developed. The biological monitoring program has shown that the average incidence of signs increases above 1% when TDG exceeds 115%. When fish are exposed to gas levels greater than 120%, there is an increasing trend in incidence and severity of these signs. The most severe signs display a similar trend above 125%. For example, 2 of the last 5 years, 1996 and 1997, were characterized by high volumes of involuntary spill with TDG levels ranging from 130% to 140% for days. In these 2 years, the incidence of GBT signs was 3.2% to 3.3% of the fish observed. In 1995, 1998, and 1999, the signs ranged from 0.04% to 0.7% of all fish sampled, demonstrating the effect of biological opinion spill levels with TDG levels managed to 115% and 120% in the project forebays and tailraces, respectively.

The biological monitoring program has established action criteria to reduce the level of TDG based on the incidence of GBT signs. Actions should be taken if 15% of the fish examined exhibit any bubbles on unpaired fins, or if 5% of the fish examined exhibit bubbles covering 25% or more of the surface of any unpaired fin. The action levels are a conservative interpretation of previous biological research results. These action levels have been reached only during high water, e.g., involuntary spill, conditions.

Appendix E reviews the early studies of TDG biological effects, including mortality, GBT signs, and depth compensation as reported in the 1995 risk assessment. More recent research in these areas is also reported. Work on GBT signs has demonstrated the incidence, severity, progression, and relevance of signs in fish. It has been shown that GBT signs correlate with exposure, are progressive, and are useful in understanding the biological implications of TDG exposure.

A critical point assumed in the early risk assessment was that fish migrate at a protective or compensatory depth. Studies since 1995 have shown that juveniles travel at depths sufficient to negate predicted mortalities from the earlier 1970s laboratory studies conducted in shallow conditions. Furthermore, studies of adult swimming depths, currently under way, reveal similar findings. Adults have been tagged with radio transmitters capable of detecting and recording travel depths. The findings thus far indicate that the fish move at depths that would compensate for TDG of 115% to 140%.

The 5 years of physical monitoring have demonstrated a sensitive and accurate monitoring system. During water years characterized by runoff volumes where the spill is due primarily to the biological opinion voluntary spill program, the TDG produced is accurately detected, and spill adjustments can be made to restrict gas below the 120% level. TDG monitoring also detects excursions above 120% TDG caused by involuntary spill during high water years with large freshet volumes. Physical monitoring has also recorded the beneficial effects of the various gas abatement efforts implemented over the last 5 years in the hydrosystem.

6.2.6.2 Water Temperature

Hydroelectric dams have modified natural temperature regimes in the mainstream Columbia River. Snake River basin storage reservoirs are known to affect water temperatures (Yearsley 1999), by extending water residence times and by changing the heat exchange characteristics of affected river reaches. In particular, seasonal temperature fluctuations generally decrease below larger storage reservoirs that thermally stratify and that have hypolimnetic discharges. Downstream temperatures are cooler in the summer as cold hypolimnetic waters are discharged, but warmer in the fall as energy stored in the epilimnion during the summer is released (Spence et al. 1996). Because of the thermal storage provided by these large reservoirs, seasonal variations in downstream temperatures are reduced in much the same way as seasonal variations in streamflow.

Lower Columbia and Snake River FCRPS reservoirs are considered run-of-river reservoirs with reduced water residence time compared with large storage projects. Mainstem run-of-river reservoirs generally have relatively weak thermal stratification. Thus, in those reservoirs, water temperature will be relatively uniform from top to bottom. The FCRPS reservoirs can also affect water temperatures, however, by extending water residence times and changing the heat exchange characteristics in the lower Snake and Columbia rivers, compared with an unimpounded river (Yearsley 1999). The Independent Scientific Group (ISG 1996) concluded that "mainstem reservoirs in the Snake and Columbia rivers have created shallow, slow-moving reaches of shorelines where solar heating has raised temperatures of salmon rearing habitat above tolerable levels," and that the operation of "storage impoundments in the Columbia River basin [has] shifted annual peak temperatures of the mainstem . . . to later in the season, when late summer and fall migrating salmonids encounter them."

Water temperature conditions have a complex array of effects on salmonids. Intergravel water temperatures affect the rate of embryonic development, with about 1,000 degree-days needed for incubation and emergence (Weatherley and Gill 1995). Post-emergence growth rates are directly related to water temperature. Water temperatures experienced by migrating juvenile salmon have been shown to affect survival (Connor et al. 1998, Smith et al. 1998, Muir et al. 1999).

An emerging issue is potential water temperature effects on juvenile migration timing. It is known that juvenile fall chinook now migrate up to 4 weeks later than they did before development of the Hells Canyon Complex and the Corps' four lower Snake River projects. The working hypothesis is that juvenile migration timing during incubation and early rearing life stages is delayed by cooler than historical water temperatures, which occur primarily above the Lower Snake projects but directly below the Hells Canyon Complex. This effect may be exacerbated by delayed spawning due to excessively warm fall temperatures. Because water temperatures and juvenile salmon mortality rates increase from mid-July through mid-September, delayed outmigration timing reduces juvenile fall chinook survival through Lower Granite Reservoir.

During July and August of some years, warm water from the lower Snake River enters the Columbia River in the McNary pool. This warm water plume tends to stay along the south bank as it approaches McNary Dam.

Turbine unit operations at McNary Dam during the summer low flow and warm temperature condition can influence the temperature of water drawn into the juvenile fish collection gallery.

Thermal profile data collected at McNary Dam have been used to develop special powerhouse operations (i.e., north powerhouse loading) to partially alleviate the potential for thermal stress on juvenile summer migrants that are collected for transportation. Even when south powerhouse units are not operated, however, warm water from along the south shoreline can still be drawn toward the northern operating turbine units.

Immigrating adults can be delayed by excessively warm water temperatures (Karr et al. 1998). In addition, fall chinook spawning is inhibited by temperatures above 61°F (16°C) (McCullough 1999). Delay can reduce the ability of adult fish to survive to spawning and vigor and fecundity during spawning. Water temperature also indirectly affects salmon survival. Foraging rates of piscivorous fish are directly related to temperature (Vigg and Burley 1991), and the rates of infectivity and mortality of several diseases are known to be directly related to temperature.

Thus, operation of storage reservoirs affects both the thermal characteristics of the river and the thermally regulated aspects of salmon survival. For this reason, the thermal effects of reservoir operation are an important consideration in developing system operations aimed at protecting and restoring listed salmonids.

Water temperature also affects the rate of physiological development in smolts. Zaugg and Wagner (1973) and Zaugg (1981) found that exposure of steelhead smolts to water temperatures greater than 12°C resulted in reduced ATPase activity and migratory behavior. Because dams cause migrational delay, smolts are exposed to seasonal increases in water temperature that can result in increased rates of residualism. The effects of increased water temperatures on other salmonids is less clear and warrants further investigation.

6.2.6.2.1 Operation of Dworshak Reservoir to Control Snake River Water Temperatures. Lower Granite Reservoir occupies the Snake River from river mile (RM) 108 to RM 148 and backs water into the Snake and Clearwater rivers a few miles upstream of their confluence near Lewiston, Idaho. It is the first major reservoir encountered by emigrating Snake River juvenile salmon and the last major reservoir negotiated by immigrating adults. A substantial portion of juvenile fall chinook salmon mortality occurs in Lower Granite Reservoir (Smith et al. 1998, Connor et al. 1998, Muir et al. 1999).

During the summer, all emigrating juveniles collected at Lower Granite Dam are transported to release points downstream of Bonneville Dam, the lowermost dam on the Columbia River. In recent years, up to 50% of the outmigrating Snake River fall chinook juveniles passing Lower Granite Dam have been collected and transported (Peters et al. 1999). For these transported fish, Lower Granite Reservoir is the last reservoir transited during their seaward migrations.

Survival of PIT-tagged juvenile fall chinook salmon from release points in the Snake and Clearwater rivers to Lower Granite Dam is strongly correlated with water temperature, as well as flow and turbidity, in Lower Granite Reservoir (NMFS 2000h). To minimize water temperature-related effects on juvenile fall chinook, Dworshak Dam on the North Fork Clearwater, about

2 river miles upstream of the Clearwater River and 60 miles from Lower Granite Reservoir, is routinely operated to release large amounts of cool water during the months of July and August to reduce water temperatures in Lower Granite Reservoir and downstream reaches. Dworshak Reservoir is a deep impoundment (over 600 feet at full pool) that stratifies in the summer, and Dworshak Dam is equipped with a variable-intake depth-release structure that facilitates selecting a specific discharge water temperature. During July and August reservoir managers typically release water at 48° to 50°F (9° to 10°C) at the request of regional salmon managers. Cooler releases are possible but may result in adverse juvenile salmon growth conditions at a downstream hatchery and the Clearwater River. This operation reduces ambient water temperature by approximately 4° to 6°F (-2° to -3°C) at Lower Granite Dam when elevated temperatures are a concern in the Snake River (July and August).

6.2.7 Effects of Predator Control Programs on Salmonid Migration and Survival—General Considerations

Dams and reservoirs are generally believed to have increased the incidence of predation over historical levels (Poe et al. 1994). Impoundments in the Columbia River basin increase the availability of microhabitats in the range preferred by northern pikeminnow and other predators (Faler et al. 1988, Beamesderfer 1992, Mesa and Olson 1993, Poe et al. 1994). They also can increase local water temperatures, which increases digestion and consumption rates by northern pikeminnow (Falter 1969, Steigenberger and Larkin 1974, Beyer et al. 1988, Vigg and Burley 1991, Vigg et al. 1991); decrease turbidity, which may increase capture efficiency of predators (Gray and Rondorf 1986); favor introduced competitors, which could cause some predators to shift to a diet composed largely of juvenile salmonids (Poe et al. 1994); and increase stress and subclinical disease of juvenile salmonids, which could increase susceptibility to predation (Rieman et al. 1991, Gadomski et al. 1994, Mesa 1994). In addition, dam-related passage problems and reduced river discharge can affect the availability, distribution, timing, and aggregation of migrating salmonids, thereby increasing exposure time to predation (Raymond 1968, 1969, 1979, 1988; Park 1969, Van Hyning 1973, Bentley and Raymond 1976). In particular, they can increase exposure time later in the season, when predator consumption rates are high (Beamesderfer et al. 1990, Rieman et al. 1991).

6.2.7.1 Effects of FCRPS Predator Control Measures on Salmonid Migration and Survival

Northern pikeminnow predation throughout the Columbia and Snake rivers was indexed in 1990-1993 based on electrofishing catch rates of predators and the occurrence of salmonids in predator stomachs relative to estimates in John Day Reservoir (Ward et al. 1995). Northern pikeminnow abundance was estimated to total 1.8 million, and daily consumption rates averaged 0.06 salmonids per predator (Beamesderfer et al. 1996). Average index values for predation losses relative to the estimate for John Day Reservoir are reported on Table 9 in NMFS (2000f). These index values would translate into 16.4 million juvenile salmon and steelhead consumed annually by northern pikeminnow, based on numbers observed in John Day Reservoir. This is 8% of the approximately 200 million hatchery and wild juvenile salmonid migrants in the system. Other work corroborates findings for the Snake River (Chandler 1993, Curet 1993) and the mid-Columbia between Priest Rapids and Chief Joseph dams (Burley and Poe 1994).

Predator control fisheries have been implemented in the Columbia basin since 1990 to harvest Northern pikeminnow with a goal of 10% to 20% exploitation, annually. From 1991 to 1996, three fisheries (sport-reward, dam angling, and gill net) harvested approximately 1.1 million northern pikeminnow greater than or equal to 250 mm fork length. Total exploitation averaged 12.0% (range, 8.1% to 15.5%) for 1991 to 1996.

Modeling results indicate that potential predation on juvenile salmonids by northern pikeminnow has decreased 25% since fishery implementation. Friesen and Ward (1999) estimated a long-term reduction in potential predation of 3.8 million juvenile salmonids per year if northern pikeminnow exploitation rates are maintained at mean levels. Projected estimations of systemwide percent reduction in juvenile salmonid mortality from predation by northern pikeminnow (relative to pre-1990 levels) due to the predator control program is 13.0% for 1992 to 1999 and 14.9% for 2000 to 2006 (Table 10, D. Ward and H. Schaller, pers. comm. to PATH Hydro Work Group, March 16, 1999). The mortality reduction estimates are derived from a spreadsheet model based on predator population size structure and the mean total pikeminnow exploitation rate estimates (D. Ward, ODFW, pers. comm., July 29, 1999).

The annual systemwide reduction in pikeminnow predation is projected to level off at about 15% during 2000 to 2006 (Figure 1 in NMFS 2000f, page 17). The mortality reduction below Bonneville Dam shows a similar trend and magnitude. The mortality reduction in the lower Columbia River reservoirs also shows a similar trend, but a higher magnitude (i.e., a future projection of about 18%). The highest estimated predation mortality reductions are in The Dalles Reservoir, over 30% annual reductions during 1996 through 2006. Pikeminnow populations and predation on salmonids are relatively low in McNary Reservoir, with low potential from predation reductions. The three lower Snake River reservoirs were intermediate (5% to 11%) during 1993 through 1998, and are projected to level off at about 3% to 4% reductions for 1999 through 2006. Lower Granite has 0% reductions due to negligible populations of northern pikeminnow.

6.2.8 Effects of FCRPS Juvenile Fish Transportation Program on Salmonid Migration and Survival

Transportation increases the survival of listed species from Lower Granite, Little Goose, Lower Monumental, or McNary Dam, to the river below Bonneville Dam, compared with survival of fish left to migrate inriver. Research has shown that the return of adults, collected and transported as juveniles, is higher than that of juvenile fish that are left to migrate inriver (NMFS 2000i).

The juvenile fish transportation program reduces adverse effects in downstream migrating juvenile salmon and steelhead from adverse environmental conditions created by Corps dams and reservoirs on the lower Snake and lower Columbia rivers. Juvenile salmon and steelhead are collected and transported from Lower Granite Dam, located at RM 107.5 on the Snake River, Washington, to the Columbia River below Bonneville Dam, located at RM 146.1, about 40 miles upstream of Portland, Oregon. Endangered SR sockeye, threatened SR chinook, and threatened SR steelhead are collected along with unlisted hatchery and wild salmon and unlisted hatchery steelhead at Lower Granite, Little Goose, and Lower Monumental dams on the Snake River. At McNary Dam, on the Columbia River, transportation of spring migrants continues to be suspended, so primarily summer migrants are transported from that location, although limited numbers of listed endangered hatchery and wild UCR steelhead and spring chinook and threatened MCR steelhead are incidentally collected and transported from McNary Dam. Listed and unlisted hatchery and wild salmon and steelhead are transported by truck and barge past three to seven downstream reservoirs and dams. Survival of endangered and threatened species is enhanced because they are transported around reservoirs and dams, where higher mortality would occur than in the transportation process. From 1995 through 1999, the juvenile fish transportation program has been carried out in accordance with the 1995 RPA, the 1998 Supplemental FCRPS Biological Opinion, ESA Section 10 Permit 895, and operating criteria in the Corps' annual Fish Passage Plan.

From the time juveniles enter the fish collection systems until they are loaded on barges, juvenile fish mortality is documented. Since 1994 at Lower Granite Dam, total collection mortality has been 0.2% or less. Yearling chinook mortality has ranged from 0.3% to 0.9%, wild steelhead mortality has been less than 0.1%, and wild subyearling chinook mortality has ranged from 0.4 to 3.6%. Sockeye salmon mortality has ranged from 0.3% to 5.1%, with 0.3% in 1998. At Little Goose Dam, overall mortality has ranged from 0.3% to 0.8% since 1994. Yearling wild chinook mortality ranged from 0.6% to 2.1%, wild steelhead from 0.1% to 0.3%, and wild subyearling chinook from 1.4% to 7.7%. Sockeye salmon mortality ranged from 2.3% to 8.9% over the same period. Overall mortality at Lower Monumental Dam since 1994 has ranged from 0.1% to 0.4%. Yearling wild chinook mortality ranged from 0.1% to 0.5%, wild steelhead from 0.1% to 0.3%, and wild subyearling chinook from 0.4% to 2.1%. Sockeye salmon mortality ranged from 0.0% to 4.0% over the same period. At McNary Dam facility mortalities have ranged from 0.4% to 1.5%. Yearling chinook morality has ranged from 0.1% to 1.1%, subyearling chinook from 0.5% to 2.1%, and sockeye salmon from 0.1 to 1.9. With the exception of McNary Dam, seasonal mortality since 1994 has been less than 1% at the collector dams. In the trucks and barges, observed seasonal mortality typically is less than 1% (Corps' application for Section 10 permit, November 18, 1999).

Under the 1994-to-1999 existing condition, the average proportion of the Snake River mixed stock yearling chinook population collected and transported from the three Snake River collector dams is estimated at 72% (ranging from 64% to 89%, depending on river conditions). For summer-migrating SR fall chinook, the overall proportion of the population collected and transported is small, because significant mortality occurs before the fish reach Lower Granite.

Similarly, the proportion of fall chinook potentially collected and transported averages about 48% and ranges from 27% to 62%, depending on river conditions (see Table 6.2-7). For SR steelhead, under the 1994-to-1999 existing condition, the average proportion transported is estimated at 77%, with a range of 71% to 89%. Post-season estimates of the proportion of wild Snake River yearling chinook transported from 1995 to 1998 range from 55% to 85% (1998 Supplemental FCRPS Biological Opinion, and Graves 1998).

Without transportation, survival of combined mixed-stock Snake River yearling chinook salmon from Lower Granite Dam to below Bonneville Dam for the 1994-to-1999 existing condition is estimated at 41%, ranging from 27% to 52%, depending on river conditions. With transportation, combined transport and inriver survival to below Bonneville Dam is estimated at 80%, ranging from 74% to 88%, also depending on river conditions. For summer-migrating Snake River fall chinook, the proportion of the population surviving to below Bonneville Dam without transportation is estimated at 10% for the 1995-to-1999 existing condition, ranging from about 1% to 16%. With transportation, estimates of the proportion of the population surviving to below Bonneville range from 26% to 61% (Table 6.2-7). For Snake River steelhead, the proportion of the population surviving to below Bonneville Dam without transportation is estimated at 41% for the 1994-to-1999 condition, ranging from about 32% to 47%. With transportation, combined transport and inriver survival to below Bonneville Dam is estimated at 82%, ranging from 79% to 87% (Table 6.2-7).

6.2.9 Summary of Effects of Proposed Action in Action Area

The following sections describe the effects of the proposed action in the action area for each of the 12 listed Columbia River basin ESUs. The action area is defined by NMFS regulations (50 CFR Section 402) as "all areas to be affected directly or indirectly by the Federal action and not merely the area involved in the action." The action area includes designated critical habitats within the Columbia River basin and estuary (58 FR 68546 for Snake River salmon and 65 FR 7765 for all other Columbia River basin salmonids), an area that serves as a migratory corridor for adult and juvenile life stages of listed anadromous fish and as a rearing area for juveniles.[7]

The following discussion is organized by the primary constituent elements of those critical habitat types that are relevant to salmonids: 1) juvenile rearing areas; 2) juvenile migration corridors; 3) areas for growth and development to adulthood; 4) adult migration corridors; and 5) spawning areas (Section 5.2.1). Essential features of each type of critical habitat, specified in Sections 5.2.1.1 through 5.2.1.5, include adequate water quality (TDG and temperature), water

[7] Marine habitats (i.e., including the Columbia River plume) are also vital to salmon and steelhead, and ocean conditions are believed to have a major influence on the species' survival. Although NMFS has not included the Pacific Ocean as critical habitat in its final rules on critical habitat (65 FR 7746), the agency will reevaluate this issue and may propose including specific marine zones for salmon and steelhead ESUs in a separate notice. However, regardless of the specific areas designated, Federal agencies are required to ensure that their actions, regardless of whether they occur in freshwater, estuarine, or marine habitats, do not jeopardize the continued existence of a listed species.

Table 6.2-7. Project and system survival and the proportion of juvenile Snake River spring/summer and fall chinook salmon and steelhead outmigrants transported under a range (1994 to 1999) of flow conditions as estimated using NMFS' spreadsheet model (SIMPAS).[1]

	Project Survival (% Dam + Pool Survival)													
YEAR	**LGR**	**LGS**	**LMN**	**IHR**	**MCN**	**JDA**	**TDA**	**BON**	**% Inriver Survival (LGR to BON)**	**% Inriver Survival (MCN to BON)**	**Prop. ESU Transported**	**% Total System Survival**	**% Total System Survival with D**	
SR spring/summer chinook salmon													D=0.63	D=0.73
1994	93.6	83.0	84.7	89.0	85.8	77.3	84.5	82.9	27.2	46.4	89.2	88.1	55.8	64.5
1995	90.6	88.2	92.5	93.6	93.6	85.2	87.2	86.9	41.8	60.4	64.0	73.5	50.3	56.6
1996	97.9	92.6	92.9	87.0	87.0	84.4	86.9	87.0	40.6	55.5	70.9	79.9	54.2	61.1
1997	91.3	94.2	89.4	89.3	89.3	83.3	86.5	86.9	38.4	56.0	65.5	74.3	50.6	57.1
1998	92.4	98.5	85.3	95.7	95.7	82.2	87.7	88.0	45.1	60.8	72.0	80.4	54.3	61.4
1999	94.1	95.0	92.5	95.1	95.1	85.3	89.3	91.1	51.9	66.0	72.2	82.4	56.1	63.2
6-yr avg	93.3	91.9	89.5	91.6	91.1	82.9	87.0	87.2	40.8	57.5	72.3	79.8	53.6	60.6
SR fall chinook salmon													D=0.24	
1994	No data collected in 1994													
1995	66.8	89.0	79.5	87.8	82.0	73.8	81.5	80.4	16.4	39.6	59.6	59.1	14.7	
1996	47.9	89.8	78.2	87.3	82.8	72.7	81.1	79.1	11.3	38.6	42.4	42.2	10.6	
1997	35.3	56.6	64.4	63.5	54.6	34.0	63.9	50.4	0.5	6.0	26.5	26.0	6.2	
1998	55.8	77.1	92.1	87.8	83.0	73.7	81.5	80.2	13.9	39.9	48.1	47.7	11.9	
1999	76.6	66.5	89.0	80.4	74.3	59.5	76.2	70.3	8.6	23.7	61.8	61.1	15.0	
5-yr avg	56.5	75.8	80.6	81.4	75.3	62.7	76.8	72.1	10.2	29.6	47.7	47.2	11.7	

Table 6.2-7 (continued). Project and system survival and the proportion of juvenile Snake River spring/summer and fall chinook salmon and steelhead outmigrants transported under a range (1994 to 1999) of flow conditions.

YEAR	Project Survival (% Dam + Pool Survival) LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON	% Inriver Survival (LGR to BON)	% Inriver Survival (MCN to BON)	Prop. ESU Transported	% Total System Survival	% Total System Survival with D	
SR steelhead													D=0.52	D=0.56
1994	90.0	84.4	89.2	90.8	88.2	81.3	85.8	85.0	32.2	52.3	89.0	87.4	45.5	49.0
1995	94.4	88.9	95.0	92.7	92.6	88.4	88.1	88.7	47.8	64.0	71.4	80.7	47.1	49.9
1996	93.4	93.8	93.7	88.9	88.9	86.0	87.3	87.8	42.8	58.6	74.8	81.6	46.4	49.3
1997	96.3	96.6	90.2	91.3	91.4	85.1	87.0	88.0	45.5	59.5	78.5	85.4	48.5	51.6
1998	92.5	93.0	88.9	89.3	89.3	83.1	89.7	91.8	41.8	61.1	75.0	80.8	45.6	48.6
1999	90.8	92.6	91.5	91.3	91.3	92.0	84.0	81.2	40.2	57.3	73.1	79.0	44.6	47.5
6-yr avg	92.9	91.7	91.4	90.7	90.3	85.8	87.0	86.9	41.5	58.6	77.0	82.4	46.3	49.3

[1] Values shown are estimates, based on juvenile survival studies rather than adult returns, and representing the expected performance of mixed (wild + hatchery) runs. Spring/summer chinook salmon and steelhead are yearling migrants; fall chinook salmon are subyearling migrants.

quantity, and water velocity; cover or shelter; food, air, light, minerals, or other nutritional or physiological requirements; riparian vegetation; substrate, space for population growth and normal behavior, and safe passage conditions.

The following sections summarize the effects of the proposed action on these essential features of critical habitat within the action area for the 12 ESUs of salmon and steelhead evaluated in this biological opinion. The discussion begins with summary tables (Tables 6.2-8 and 6.2-9) that indicate whether each species' biological requirements are likely to be affected by the proposed action. In some cases, NMFS is uncertain whether or not there will be an effect, as described in the accompanying text.

6.2.9.1 Snake River Spring/Summer Chinook Salmon

6.2.9.1.1 Juvenile Rearing Areas. SR spring/summer chinook salmon rear in tributary systems to the mainstem Snake River and do not have biological requirements for rearing habitat within the action area.

6.2.9.1.2 Juvenile Migration Corridors

Juvenile SR spring/summer chinook salmon are yearling migrants, with downstream movement during April through June.

Water Quality. Biological monitoring during the previous 5 years shows that the incidence of GBT in migrating smolts remains below 1% when dissolved-gas concentrations in the upper water column do not exceed 115%. During the spring and early summer in high-volume water years (e.g.,1996 and 1997), involuntary spill has caused TDG to exceed the state water quality standard (110%) and waiver levels of 120% in tailraces and 115% in forebays, with a corresponding increase in the incidence of signs of GBT. Studies since 1995, however, indicate that juveniles avoid exposure by traveling at dissolved gas "compensation" depths (Section 6.2.6.1).

Juvenile spring migrants through FCRPS reservoirs are not subject to thermal effects under the proposed action (Section 6.2.5.2).

Water Quantity/Water Velocity/Cover/Shelter. Although yearling chinook salmon move relatively quickly through the FCRPS, they have biological requirements for cover and shelter in the sense of refuge from predators. NMFS has not detected a relationship between flow and survival for yearling chinook salmon in the Lower Granite-to-McNary reach. NMFS has demonstrated a strong and consistent relationship between travel time and flow for spring migrants below McNary Dam, where northern pikeminnow predation rates are particularly high. By decreasing the residence time of yearling smolts in the lower river, higher spring flows may reduce exposure time to predators. This hypothesis is supported by relationships between SARs or R/S and seasonal flows. Under the proposed action, the likelihood of meeting or exceeding

Table 6.2-8. Summary of the effects of the proposed action on essential features of critical habitat within the action area for five ESUs of chinook salmon and for chum salmon in the Columbia River basin.

Essential Habitat	Chinook Salmon					Chum Salmon
	SR Spring/ Summer	SR Fall	UCR Spring	UWR	LCR[1]	
Juvenile Rearing Areas						
— Water quality	NR	E	NR	NR	E	E
— Water quantity/velocity	NR	E	NR	NR	E	E
— Food	NR	U	NR	NR	E	E
— Cover/shelter	NR	N	NR	NR	E	E
— Riparian vegetation	NR	N	NR	NR	E	E
— Space	NR	N	NR	NR	E	E
— Migration conditions	NR	E	NR	NR	E	E
Juvenile Migration Corridors						
— Water quality	E	E	E	N	E	E
— Water quantity/velocity	E	E	E	N	N	E
— Cover/shelter	E	U	E	N	N	E
— Food	U	N	U	U	U	U
— Riparian vegetation	NR	N	NR	U	U	NR
— Space	N	N	N	N	U	N
— Migration conditions	E	E	E	N	E	U
Areas for Growth and Development to Adulthood	U	U	U	U	U	U
Adult Migration Corridor						
— Water quality	E	E	E	E	E	N
— Water quantity/velocity	E	E	E	N	E	N
— Food	NR	NR	NR	NR	NR	NR
— Cover/shelter	N	N	N	N	N	N
— Riparian vegetation	NR	NR	NR	NR	NR	NR
— Space	N	N	N	N	N	N
— Migration conditions	E	E	E	N	E	E
Spawning Areas						
— Water quality	NR	U	NR	NR	U	N
— Water quantity/velocity	NR	U	NR	NR	E	E
— Food	NR	NR	NR	NR	NR	NR
— Cover/shelter	NR	NR	NR	NR	NR	NR
— Riparian vegetation	NR	NR	NR	NR	NR	NR
— Space	NR	U	NR	NR	E	E
— Migration conditions	NR	U	NR	NR	E	E
— Substrate	NR	U	NR	NR	E	E

Note: NR = no biological requirement, E = effect (magnitude may be unknown), U = uncertain, N = no effect.
[1] Effects on spawning and rearing areas for LCR chinook salmon apply only to the Ives Island area below Bonneville Dam where this species spawned in October 1999.

Table 6.2-9. Summary of the effects of the proposed action on essential features of critical habitat within the action area for five ESUs of steelhead and for sockeye salmon in the Columbia River basin.

	Steelhead					
Essential Habitat	**SR**	**UCR**	**MCR**	**UWR**	**LCR**	**Sockeye Salmon**
Juvenile Rearing Areas	NR	NR	NR	NR	NR	NR
Juvenile Migration Corridors						
— Water quality	E	E	E	E	E	E
— Water quantity/velocity	E	E	E	N	N	E
— Cover/shelter	E	E	E	N	N	E
— Food	U	U	U	U	U	U
— Riparian vegetation	NR	NR	NR	NR	NR	NR
— Space	N	N	N	N	N	N
— Migration conditions	E	E	E	N	E	E
Areas for Growth and Development to Adulthood	U	U	U	U	U	U
Adult Migration Corridor						
— Water quality	E	E	E	E	E	E
— Water quantity/velocity	E	E	E	E	E	E
— Food	NR	NR	NR	NR	NR	NR
— Cover/shelter	N	N	N	N	N	N
— Riparian vegetation	NR	NR	NR	NR	NR	NR
— Space	N	N	N	N	N	N
— Migration conditions	E	E	E	N	E	E
Spawning Areas	NR	NR	NR	NR	NR	NR

Note: NR = no biological requirement, E = effect (magnitude may be unknown), U = uncertain, N = no effect.
[1] Effects on spawning and rearing areas for LCR chinook salmon apply only to the Ives Island area below Bonneville Dam where this species spawned in October 1999.

flow objectives at Lower Granite and McNary dams during the spring migration season (late April, May, and June) is 68% or less (Table 6.2-5).

Riparian Vegetation/Space. Because yearling chinook salmon migrate midchannel through FCRPS reservoirs (Battelle and USGS 2000), they do not have biological requirements for riparian vegetation in the juvenile migration corridor. Further, there is no evidence that the reservoir environment has resulted in loss of the amount of physical habitat required by yearling migrants in the migration corridor (Battelle and USGS 2000).

Food. NMFS is uncertain whether yearling migrants have a biological requirement for food in the juvenile migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Migration Conditions. Using SIMPAS, the Biological Effects Team and NMFS estimated that an average of 72% of the run was transported from the Snake River collector projects during 1994 through 1999 (Table 6.2-7). The rest of the run migrated inriver past eight FCRPS projects. The direct survival of transported juveniles over the same period was at least 98%, and NMFS estimates that the average system survival rate of inriver migrants was approximately 41%. The total (transported plus inriver) system survival rate for SR spring/summer chinook salmon ranged on average from 54% to 61% (depending on the level of differential mortality of transported fish assumed in the SIMPAS analysis).

6.2.9.1.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling SR spring/summer chinook salmon. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.1.4 Adult Migration Corridors

Water Quality. Biological monitoring over the previous 5 years has shown that the incidence of signs of GBT in migrating adults remains below 1% when TDG concentrations in the upper water column do not exceed 115%. During spring and early summer in high-volume water years (e.g., 1996 and 1997), involuntary spill has caused TDG to exceed state water quality standard waiver levels of 120% in tailraces and 115% in forebays, with a corresponding increase in the incidence of signs of GBT. However, studies since 1995 indicate that adults avoid exposure by traveling at dissolved gas “compensation” depths (Section 6.2.6.1).

High water temperatures (i.e., generally considered to be greater than 68°F (20°C) for salmonids) are observed systemwide during late summer and early fall, due in part to thermal storage in FCRPS reservoirs (Section 6.2.6.2). However, because SR spring/summer chinook salmon migrate through FCRPS reservoirs before July, adults from this ESU are not subject to these thermal effects.

Water Quantity/Velocity. Travel time and energy expenditures of upstream migrants are lower in reservoirs than in free-flowing rivers. Adults may be delayed in the tailrace or adult collection channel, but once they begin to ascend the ladder, delays are minimal. Under the proposed action, delay will be minimized by operating to meet water velocity and flow criteria at fishway entrances and channels. The net effect of delay at lower Snake River dams, combined with faster passage through reservoirs, is a median travel time at least as fast with dams in place as with no dams.

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. SR spring/summer chinook salmon do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Based on recent radio-tracking studies, the mean survival rate of adult migrants between Bonneville and Lower Granite dams is 82%, equivalent to a per-project survival rate of 98% (Table 6.1-1).

6.2.9.1.5 Spawning Areas. SR spring/summer chinook salmon do not have biological requirements for spawning habitat within the action area.

6.2.9.2 Snake River Fall Chinook Salmon

6.2.9.2.1 Juvenile Rearing Areas and Migration Corridors

Juvenile SR fall chinook salmon are subyearling migrants, moving downstream during June through September and rearing during at least part of this period.

Water Quality. The potential for adverse affects on dissolved gas conditions under the proposed action is lower than described above for SR spring/summer chinook salmon, because involuntary spill is extremely unlikely during the summer migration season.

Conversely, high water temperatures are observed systemwide during summer and early fall. As described in Section 6.2.6.2, the survival of juvenile fall chinook through Lower Granite Reservoir may be reduced by an interaction between the thermal effects of FCRPS operations and Idaho Power Company's operations at its Hells Canyon Complex. Under the proposed action, cooler water will be released from Dworshak Reservoir during the late summer to reduce water temperatures in the reach between Lower Granite Reservoir and Ice Harbor Dam.

Water Quantity/Velocity. NMFS' research has identified strong, positive relationships between the survival of subyearling migrants and flow, temperature, and turbidity. Operations at dams change under lower flows (e.g., less spill, greater diel-flow fluctuations) in ways that can decrease fish survival. FGEs of subyearling chinook decrease at higher temperatures, so more fish are likely to pass through turbines. Further, vulnerability to sight-feeding predators increases as flows and turbidity decrease. The likelihood of meeting mainstem flow objectives at Lower Granite and McNary dams during the summer migration season varies from 40% to 68% (Lower Granite Dam during July and June) to no more than 8% (both locations during August) (Table 6.2-5).

Cover/Shelter/Riparian Vegetation. Subyearling fall chinook salmon in the lower Snake River reservoirs are either pelagic-oriented or found over sandy, mostly unvegetated substrate (Section 6.2.5.3.2). Although it is uncertain whether subyearlings have biological requirements for cover, shelter, and vegetation (beyond the effect of mainstem flow as a potential refuge from predation; see above), there is no indication that the proposed action will have adverse effects on these elements of rearing habitat in the action area.

Space. There is no evidence that the reservoir environment has resulted in loss of the amount of physical habitat required by subyearling migrants in the migration corridor (Battelle and USGS 2000).

Food. Subyearling SR fall chinook have a biological requirement for food in the juvenile migration corridor/rearing area. Prey resources in mainstem reservoirs are different than those in free-flowing reaches (e.g., terrestrial insects and zooplankton predominate in reservoirs versus aquatic insects in the free-flowing river). NMFS is uncertain, however, whether this change in prey assemblage adversely affects biological requirements for food during this life stage. Similarly, although water level fluctuations associated with reservoir operations could affect the life cycles of invertebrate prey in the littoral zone, the 1995 RPA required the Corps to operate the lower Snake River pools within 1 foot of minimum operating pool, minimizing the disruption of shallow water habitat.

Migration Conditions. Juveniles are summer migrants with peak movement past Lower Granite Dam during July. Using SIMPAS, NMFS estimated that an average of 48% of the run was transported from the Snake River collector projects during 1995 through 1999 (Table 6.2-7). The rest of the run migrated inriver past eight FCRPS projects. The direct survival of transported juveniles was at least 98%, and NMFS estimates that the average system survival rate of inriver migrants over the same period was approximately 10%. The total (transported plus inriver) system survival rate for SR fall chinook salmon was, on average, approximately 12%.

6.2.9.2.2 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River estuary and plume that in turn affect the growth and survival of subyearling SR fall chinook salmon. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.2.3 Adult Migration Corridors

Water Quality. FCRPS operations interact with effects of operations at the Hells Canyon Complex to increase water temperatures in the lower Snake River from mid-July through mid-September. Adults entering the Snake River during this period can be delayed by elevated water temperatures, potentially reducing fish condition and fecundity during spawning.

Water Quality/Velocity. Effects of the proposed action on biological requirements for water quantity and velocity in adult migration corridors are the same as those discussed for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. SR fall chinook salmon do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Based on recent radio-tracking studies, the mean survival rate of adult migrants between Bonneville and Lower Granite dams is 71%, equivalent to a per-project survival rate of 96% (Table 6.1-1).

6.2.9.2.4 Spawning Areas. Fall chinook salmon are known to spawn in the tailraces of Lower Granite, Little Goose, and Ice Harbor dams. The effects of FCRPS flow management on use of this spawning habitat (water quantity and velocity, space, access to habitat, and availability of suitable substrate) is unknown. Spawning may be inhibited at temperatures above 61°F (16°C). SR fall chinook salmon do not have biological requirements for food, cover, shelter, or riparian vegetation in spawning areas.

6.2.9.3 Upper Columbia River Spring Chinook Salmon

6.2.9.3.1 Juvenile Rearing Areas. Juvenile UCR spring chinook salmon rear in tributaries and migrate through the FCRPS as yearlings and do not have biological requirements for rearing habitat in the action area.

6.2.9.3.2 Juvenile Migration Corridors

Juvenile UCR spring chinook salmon are spring migrants with peak movement past Rock Island Dam in the mid-Columbia reach during late April and May.

Water Quality/Water Quantity/Water Velocity/Cover/Shelter/Food/Riparian Vegetation/Space. Effects of the proposed action on these constituent elements of critical habitat in juvenile migration corridors are similar to those discussed for SR spring/summer chinook salmon (above). The likelihood of meeting or exceeding spring flow objectives at Priest Rapids and McNary dams under the proposed action is less than 80%, except at Priest Rapids during May (86%; Table 6.2-5).

Migration Conditions. Depending on their natal tributary, juveniles pass through five (Methow River), four (Entiat River), or three (Wenatchee River) PUD projects before reaching McNary Dam. Transportation from McNary Dam has not been used as a protection measure for this ESU under existing operations. However, a portion of the run (typically less than 5%; Figure VI-5 in NMFS 2000d) may have been collected and transported in the past. Although there are no ESU-specific survival rates for UCR spring chinook salmon through FCRPS hydroprojects, NMFS assumes that they are adequately represented by data for SR spring/summer chinook salmon (total system survival rate averaged 58% during 1994 through 1999; Table 6.2-7).

6.2.9.3.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling UCR spring chinook salmon. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.3.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity. Effects of the proposed action on biological requirements for these constituent elements of critical habitat in the adult migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. SR spring/summer chinook salmon do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Based on recent radio-tracking studies with SR spring/summer chinook salmon, NMFS estimates that the mean survival rate of adult UCR spring chinook salmon from below Bonneville Dam to the head of McNary pool is 91%, equivalent to a per-project survival rate of 98% (Table 6.1-1).

6.2.9.3.5 Spawning Areas. UCR spring chinook salmon do not have biological requirements for spawning habitat in the action area.

6.2.9.4 Upper Willamette River Chinook Salmon

6.2.9.4.1 Juvenile Rearing Areas. Juvenile UWR chinook salmon rear in tributaries and migrate through the FCRPS as yearlings and do not have biological requirements for rearing habitat in the action area.

6.2.9.4.2 Juvenile Migration Corridors

Juvenile UWR chinook salmon migrate through the mainstem lower Columbia River both as yearlings and as subyearlings.

Water Quality. Most of the migration moves through the lower Columbia River during February through May, before peak spring runoff and periods of involuntary spill. Thus, biological requirements for water quality in the juvenile migration corridor will not be affected by the proposed action.

Water Quantity/Water Velocity/Cover/Shelter. Biological requirements for water quantity and velocity, cover, or shelter in the mainstem Columbia River juvenile migration corridor are not likely to be adversely affected by the proposed action. Flow objectives have not been developed to benefit UWR chinook salmon.

Food. Subyearling UWR chinook salmon migrants are likely to have a biological requirement for food in the mainstem Columbia River juvenile migration corridor. However, NMFS is uncertain whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Riparian Vegetation. NMFS is uncertain whether subyearling UWR chinook salmon have biological requirements for riparian vegetation in the mainstem Columbia River juvenile migration corridor or if such requirements will be affected by the proposed action.

Space. Biological requirements for space in the mainstem Columbia River juvenile migration corridor are not likely to be adversely affected by the proposed action.

Migration Conditions. Juvenile UWR chinook salmon do not pass any FCRPS dams and therefore are not subject to mortality during project passage.

6.2.9.4.3 Areas for Growth and Development to Adulthood. UWR chinook salmon emigrate from the Willamette River basin as a mixture of yearling and subyearling fish. Current FCRPS operations may have effects on rearing habitat in the Columbia River estuary and plume that in turn affect the growth and survival of one or both types of juvenile UWR chinook salmon. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.4.4 Adult Migration Corridors

Water Quality. Adult UWR chinook salmon migrate through the FCRPS during March through June. The latter portion of the run may be exposed to high TDG concentrations during periods of involuntary spill.

Water Quantity/Velocity/Cover/Shelter/Space. Biological requirements of adult UWR chinook salmon for water quantity and velocity and for cover, shelter, and space in the mainstem Columbia River adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. UWR chinook salmon do not have biological requirements for riparian vegetation or food in the mainstem Columbia River adult migration corridor.

Migration Conditions. Adults leave the mainstem Columbia River to enter the Willamette system below Bonneville Dam and thus are not subject to project passage mortality.

6.2.9.4.5 Spawning Areas. UWR chinook salmon do not have biological requirements for spawning habitat in the action area.

6.2.9.5 Lower Columbia River Chinook Salmon

6.2.9.5.1 Juvenile Rearing Areas

The proposed action will affect biological requirements for rearing habitat of LCR chinook salmon in the Ives Island area below Bonneville Dam, where individuals from this ESU were observed spawning once, during October 1999.

Water Quality/Quantity/Velocity. Spill operations at Bonneville Dam, such as spill for debris removal, gas generation/abatement testing, or juvenile fish passage, can create TDG concentrations high enough to kill yolk sac fry in redds in the Ives Island area. This effect can be prevented by providing flows that create a compensation depth over the redds, reducing the effective TDG concentration to 105% of saturation or less. During spring 2000, a Bonneville outflow of at least 200 kcfs was needed to create the compensation depth for Ives Island redds (i.e., redds dug at spawning flows of 125 to 165 kcfs). Under the proposed action, the likelihood of providing Bonneville outflows greater than or equal to 125 kcfs is 88% during January and 78% during February and March (Table 6.2-5).

Cover/Shelter/Food/Riparian Vegetation/Space. Data derived primarily from Ives Island brights (UCR summer/fall-run chinook salmon ESU) indicate that LCR chinook salmon are likely to have biological requirements for these elements of rearing habitat in the Ives Island area after emergence (January through July).

Migration Conditions. FCRPS flow operations affect migration conditions in the form of access to juvenile rearing habitat in the Ives Island area. Flow fluctuations can strand subyearlings, making them vulnerable to death through desiccation or avian predation.

6.2.9.5.2 Juvenile Migration Corridors

Juvenile LCR chinook salmon are primarily subyearling migrants, moving through the mainstem lower Columbia River during spring and early summer.

Water Quality. Effects of the proposed action on biological requirements for water quality in the mainstem Columbia River migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Water Quantity/Water Velocity/Cover/Shelter. Biological requirements for water quantity and velocity, cover, or shelter in the juvenile migration corridor are not likely to be adversely affected by the proposed action. Mainstem Columbia River flow objectives have not been developed to benefit LCR chinook salmon.

Riparian Vegetation. NMFS is uncertain whether subyearling LCR chinook salmon have biological requirements for riparian vegetation in the mainstem Columbia River migration corridor or if such requirements will be adversely affected by FCRPS operations.

Food. Subyearling LCR chinook salmon migrants are likely to have biological requirements for food in the mainstem Columbia River migration corridor. NMFS is uncertain, however, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Space. Biological requirements for space in the mainstem Columbia River migration corridor are not likely to be adversely affected by FCRPS operations.

Migration Conditions. Only juveniles that emerge from the Wind, Little White Salmon, and [Big] White Salmon rivers in Washington and the Hood River in Oregon encounter Bonneville Dam after entering the Columbia River. Although there are no ESU-specific survival rates of LCR chinook salmon past Bonneville Dam, NMFS assumes that these are adequately represented by data for yearling and subyearling chinook salmon migrants in the run at large. Using SIMPAS, NMFS estimated an average system survival rate of 87% for yearling migrants and 72% for subyearling migrants through Bonneville pool and dam during 1994 through 1999 (Table 6.2-7). It should be noted, however, that the potential for these effects applies to a limited number of the subbasin populations.

6.2.9.5.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River estuary and plume that in turn affect the growth and survival of subyearling LCR chinook salmon. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.5.4 Adult Migration Corridors

Water Quality/Water Quantity/Water Velocity. Effects of the proposed action on biological requirements for water quality, quantity, and velocity in the mainstem Columbia River migration corridor are different for the spring- and fall-run components of the ESU. For spring-run chinook salmon, effects are similar to those described above for SR spring/summer chinook salmon. For fall-run fish, low flows during late summer and early fall, related to high temperatures, may delay migration through the Bonneville pool and potentially lead to disease transmission between adults delayed in fish ladders. The potential for these effects, however, applies to a limited number of the subbasin populations.

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. LCR chinook salmon do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Based on recent radio-tracking studies with SR spring/summer and fall chinook salmon, NMFS estimates that the average survival rate of adult migrants from below Bonneville to tributaries to the Bonneville pool is 98% for spring-run fish and 96% for fall-run fish (Table 6.1-1). It should be noted that this type of mortality is limited to passage at one project for part of the subbasin populations.

6.2.9.5.5 Spawning Areas

The proposed action will affect biological requirements for spawning habitat of LCR chinook salmon in the Ives Island area below Bonneville Dam, where individuals from this ESU were observed spawning once, during October 1999.

Water Quality/Water Quantity/Velocity/Space/Migration Conditions/Substrate. The Action Agencies can use reservoir storage from the upper Columbia and Snake river basins to augment mainstem flows below Bonneville Dam, creating access to, and increasing the areal extent of, shallow-water spawning habitat in the Ives Island area. Under the proposed action, the likelihood of meeting a minimum spawning flow (125 kcfs at Bonneville Dam) during September and October is 20% or less (Table 6.2-5). Short-term fluctuations in flow in the Ives Island area, especially below 125 kcfs, can strand adult fall chinook and interrupt spawning. Adult LCR chinook salmon do not have biological requirements for food, cover, shelter, or riparian vegetation associated with spawning habitat. NMFS is uncertain whether FCRPS reservoir storage affects temperature in the Ives Island area during late September and early October, when tule fall chinook spawn.

Cover/Shelter/Food/Riparian Vegetation. LCR chinook salmon do not have biological requirements for cover, shelter, food, or riparian vegetation in spawning habitat.

6.2.9.6 Snake River Steelhead

6.2.9.6.1 Juvenile Rearing Areas. Juvenile SR steelhead rear in tributary systems to the mainstem Snake River and do not have biological requirements for rearing habitat in the action area.

6.2.9.6.2 Juvenile Migration Corridors

Juvenile SR steelhead migrate as yearlings, with peak movement past Lower Granite Dam during April and May.

Water Quality/Quantity/Velocity/Cover/Shelter. Effects of the proposed action on biological requirements for water quality, quantity, velocity, cover, and shelter in juvenile migration corridors are the same as those discussed for SR spring/summer chinook salmon (above).

Riparian Vegetation. Yearling steelhead migrants do not have biological requirements for riparian vegetation in the juvenile migration corridor.

Food. NMFS is uncertain whether yearling steelhead migrants have a biological requirement for food in the juvenile migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Space. Biological requirements for space in the mainstem juvenile migration corridor are not likely to be adversely affected by the proposed action.

Migration Conditions. Using SIMPAS, NMFS estimated that an average of 77% of the run was transported from the Snake River collector projects during 1994 through 1999 (Table 6.2-7). The rest of the run migrated inriver past eight FCRPS projects. The direct survival of transported juveniles over the same period was at least 98%, and NMFS estimates that the average system survival rate of inriver migrants was approximately 42%. The total (transported plus inriver) system survival rate for SR steelhead ranged from 46% to 49%, on average (depending on the level of differential mortality of transported fish assumed in the analysis).

6.2.9.6.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling SR steelhead. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.6.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity. The run timing of SR steelhead overlaps with that of both SR summer and SR fall chinook. Effects of the proposed action on biological requirements for water quality, quantity, and velocity in the adult mainstem Columbia and Snake river migration corridors are, therefore, the same as those discussed for both SR spring/summer chinook salmon and SR fall chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. SR steelhead do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Based on recent radio-tracking studies, the mean survival rate of adult migrants between Bonneville and Lower Granite dams is 77%, equivalent to a per-project survival rate of 97% (Table 6.1-1). Few downstream-migrating adult steelhead (kelts) survive to spawn a second time without passing through dams (7% to lower Columbia River tributaries). The mortality of kelts passing through FCRPS projects has not been investigated. Assuming that turbine survival is similar to that of upstream migrating adults (22% to 57%, page VI-15 in NMFS 1998), the survival of kelts past multiple dams to spawn a second time is unlikely.

6.2.9.6.5 Spawning Areas. SR steelhead spawn in tributary systems to the mainstem Snake River and do not have biological requirements for spawning habitat in the action area.

6.2.9.7 Upper Columbia River Steelhead

6.2.9.7.1 Juvenile Rearing Areas. Juvenile UCR steelhead rear in tributary systems to the mainstem Columbia River and do not have biological requirements for rearing habitat in the action area.

6.2.9.7.2 Juvenile Migration Corridors

Juvenile UCR steelhead are yearling migrants, moving through the mainstem Columbia River during spring.

Water Quality. Effects of the proposed action on biological requirements for water quality in juvenile migration corridors are the same as those discussed for SR spring/summer chinook salmon in the juvenile migration corridor (above).

Water Quantity/Velocity/Cover/Shelter. Under the proposed action, the likelihood of meeting or exceeding flow objectives at Priest Rapids and McNary dams during the spring migration season (April, May, and June) is 78% or less under the base case, except during May at Priest Rapids (86%; Table 6.2-5).

Riparian Vegetation. Yearling steelhead migrants do not have biological requirements for riparian vegetation in the mainstem Snake and Columbia river migration corridors.

Food. NMFS is uncertain whether yearling steelhead migrants have biological requirements for food in the mainstem migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Space. Biological requirements for space in the mainstem migration corridor are not likely to be adversely affected by the proposed action.

Migration Conditions. Juveniles are spring migrants with peak movement past Rock Island Dam in the mid-Columbia reach during May. Depending on their natal tributary, juveniles pass through five (Methow River), four (Entiat River), or three (Wenatchee River) mid-Columbia PUD projects before reaching McNary Dam. Under existing operations, transportation from McNary Dam has not been used as a protection measure for UCR steelhead. However, a portion of the run (typically less than 5%; Figure VI-5 in NMFS 2000d) has been collected and transported in the past. Although there are no ESU-specific survival rates of UCR steelhead through FCRPS hydroprojects, NMFS assumes that these are adequately represented by data for SR steelhead. Using SIMPAS, NMFS estimated that the total system survival rate of juvenile steelhead from the head of McNary pool to below Bonneville Dam averaged 59% during 1994 through 1999 (Table 6.2-7).

6.2.9.7.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling UCR steelhead. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.7.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity. Effects of the proposed action on biological requirements for water quality, quantity, and velocity in adult migration corridors are the same as those discussed for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. UCR steelhead do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Based on recent radio-tracking with SR steelhead, NMFS estimates that the mean survival rate of adult migrants from below Bonneville Dam to the head of McNary pool is 88%, equivalent to a per-project survival rate of 97% (Table 6.1-1).

6.2.9.7.5 Spawning Areas. UCR steelhead spawn in tributary systems to the mainstem Columbia River and do not have biological requirements for spawning habitat in the action area.

6.2.9.8 Middle Columbia River Steelhead

6.2.9.8.1 Juvenile Rearing Areas. Juvenile MCR steelhead rear in tributary systems to the mainstem Columbia River and do not have biological requirements for rearing habitat in the action area.

6.2.9.8.2 Juvenile Migration Corridors

Juvenile MCR steelhead are yearling migrants, moving through the mainstem lower Columbia River during spring.

Water Quality. Effects of the proposed action on biological requirements for water quality in the mainstem Columbia River migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Water Quantity/Velocity/Cover/Shelter. Flow objectives have not been developed to benefit MCR steelhead. However, yearling migrants from this ESU will probably benefit from flow objectives at Priest Rapids and McNary dams, developed to protect yearling migrants from the upper Columbia River basin. Under the proposed action, the likelihood of meeting or exceeding flow objectives at Priest Rapids and McNary dams during the spring migration season (April, May, and June) is 78% or less under the base case, except during May at Priest Rapids (86%; Table 6.2-5).

Riparian Vegetation. Yearling steelhead migrants do not have biological requirements for riparian vegetation in the mainstem migration corridor.

Food. NMFS is uncertain whether yearling steelhead migrants have a biological requirement for food in the juvenile migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Space. Biological requirements for space in the juvenile migration corridor are not likely to be adversely affected by the proposed action.

Migration Conditions. Juveniles are spring migrants. These fish do not pass Rock Island Dam, so there is no ESU-specific information on historical passage patterns. Only those that emigrate from the Yakima and Walla Walla subbasins encounter McNary Dam after entering the Columbia River. Under existing operations, transportation from McNary Dam has not been used as a protection measure for MCR steelhead. However, a portion of the run from the Yakima and Walla Walla subbasins has probably been collected and transported in the past. Although there are no ESU-specific survival rates of MCR steelhead through FCRPS projects, NMFS assumes that these are adequately represented by data for SR steelhead. Using SIMPAS, NMFS estimated that the average FCRPS system survival rate of juvenile steelhead from the Yakima and Walla Walla subbasins, from the head of McNary pool to below Bonneville Dam, during 1994 through

1999 was 59% (Table 6.2-7). Based on the project-specific survival rates shown in Table 6.2-7, the average system survival rates of MCR steelhead emigrating from tributaries to the John Day and The Dalles pools are, on average, approximately 65% and 76%, respectively.

6.2.9.8.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling MCR steelhead. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.8.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity. Effects of the proposed action on biological requirements for water quality, quantity, and velocity in the adult mainstem Columbia River migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult mainstem migration corridor are not likely to be adversely affected by the proposed action.

Food/Riparian Vegetation. Adult MCR steelhead do not have biological requirements for food and riparian vegetation in the mainstem Columbia River migration corridor.

Migration Conditions. Based on recent radio-tracking studies with SR steelhead, NMFS estimates that the mean survival rates of adult MCR steelhead migrants in the reach from below Bonneville Dam to the heads of The Dalles, John Day, and McNary pools are 94%, 91%, and 88%, respectively, equivalent to a per-project survival of 97% (Table 6.1-1).

6.2.9.8.5 Spawning Areas. MCR steelhead spawn in tributary systems to the mainstem Columbia River and do not have biological requirements for spawning habitat in the action area.

6.2.9.9 Upper Willamette River Steelhead

6.2.9.9.1 Juvenile Rearing Areas. Juvenile UWR steelhead rear in tributary systems to the mainstem Columbia River and do not have biological requirements for rearing habitat in the action area.

6.2.9.9.2 Juvenile Migration Corridors

Juvenile UWR steelhead are yearling migrants, moving through the mainstem lower Columbia River during spring.

Water Quality. Effects of the proposed action on biological requirements for water quality in the mainstem Columbia River migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Water Quantity/Velocity/Cover/Shelter/Space. Biological requirements for water quantity and velocity, cover, shelter, or space in the juvenile migration corridor are not likely to be adversely affected by the proposed action. Mainstem Columbia River flow objectives have not been developed to benefit juvenile UWR steelhead.

Riparian Vegetation. Yearling steelhead migrants do not have biological requirements for riparian vegetation in the mainstem Columbia River migration corridor.

Food. NMFS is uncertain whether yearling steelhead migrants have a biological requirement for food in the mainstem Columbia River migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Migration Conditions. Juvenile UWR steelhead enter the Columbia River below Bonneville Dam and thus are not subject to passage mortality.

6.2.9.9.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling UWR steelhead. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.9.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity. Effects of the proposed action on biological requirements for water quality, quantity, and velocity in the adult mainstem Columbia River migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the mainstem Columbia River migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. UWR steelhead do not have biological requirements for riparian vegetation or food in the mainstem Columbia River migration corridor.

Migration Conditions. Adults leave the Columbia River to enter the Willamette system below Bonneville Dam and thus are not subject to project passage mortality.

6.2.9.9.5 Spawning Areas. UWR steelhead spawn in tributary systems to the mainstem Columbia River and do not have biological requirements for spawning habitat in the action area.

6.2.9.10 Lower Columbia River Steelhead

6.2.9.10.1 Juvenile Rearing Areas. Juvenile LCR steelhead rear in tributary systems to the mainstem Columbia River and do not have biological requirements for rearing habitat in the action area.

6.2.9.10.2 Juvenile Migration Corridors

Juvenile LCR steelhead migrate as yearlings, moving through the mainstem lower Columbia River during spring.

Water Quality. Effects of the proposed action on biological requirements for water quality in the mainstem Columbia River juvenile migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Water Quantity/Velocity/Cover/Shelter/Space. Biological requirements for water quantity and velocity, cover, shelter and space in the mainstem Columbia River juvenile migration corridor are not likely to be adversely affected by the proposed action. Flow objectives have not been developed to benefit LCR steelhead.

Riparian Vegetation. Yearling steelhead migrants do not have biological requirements for riparian vegetation in the mainstem Columbia River migration corridor.

Food. NMFS is uncertain whether yearling steelhead migrants have a biological requirement for food in the juvenile migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Migration Conditions. There is no ESU-specific information on historical passage patterns or survival rates, but only migrants from the Wind River, Washington, and the Hood River, Oregon, encounter Bonneville Dam after entering the Columbia River. NMFS assumes that their survival rates are adequately represented by data for SR steelhead. Using SIMPAS, NMFS estimated an average survival rate of 87% through Bonneville pool and dam during 1994 through 1999 (Table 6.2-7). It should be noted, however, that the potential for these effects is limited to passage at one (i.e., Bonneville) project for part of the subbasin populations.

6.2.9.10.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling LCR steelhead. The evidence for these relationships is largely inferential, however, and is the subject of ongoing research.

6.2.9.10.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity. Effects of the proposed action on biological requirements for water quantity and velocity in the adult mainstem Columbia River migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the mainstem Columbia River migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. LCR steelhead do not have biological requirements for riparian vegetation or food in the adult mainstem Columbia River migration corridor.

Migration Conditions. Based on recent radio-tracking studies with SR steelhead, NMFS estimates that the mean survival rate of adult migrants from below Bonneville Dam to tributaries in Bonneville pool is approximately 97% (Table 6.1-1). It should be noted, however, that the potential for these effects is limited to passage at one (i.e., Bonneville) project for part of the subbasin populations.

6.2.9.10.5 Spawning Areas. LCR steelhead spawn in tributary systems to the mainstem Columbia River and do not have biological requirements for spawning habitat in the action area.

6.2.9.11 Columbia River Chum Salmon

6.2.9.11.1 Juvenile Rearing Areas. Effects of the proposed action on biological requirements for juvenile rearing habitat are the same as those discussed for LCR chinook salmon in juvenile rearing areas (above).

6.2.9.11.2 Juvenile Migration Corridors

Juvenile CR chum salmon are subyearling migrants, moving through the mainstem lower Columbia River during late winter and early spring.

Water Quality. Effects of the proposed action on the biological requirements of juvenile CR chum salmon for water quality in the mainstem Columbia River juvenile migration corridor are the same as those discussed for SR spring/summer chinook salmon (above).

Water Quantity/Velocity/Cover Shelter. Under the proposed action, the likelihood of meeting or exceeding flow objectives at Bonneville Dam during the late winter/early spring migration season is 78% (i.e., during February and March, Table 6.2-5).

Riparian Vegetation. Subyearling chum salmon migrants do not have biological requirements for riparian vegetation in the mainstem Columbia River migration corridor.

Food. NMFS is uncertain whether subyearling CR chum salmon migrants are likely to have biological requirements for food in the mainstem Columbia River migration corridor, or whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Space. Biological requirements for space in the juvenile migration corridor are not likely to be adversely affected by the proposed action.

Migration Conditions. Although chum salmon spawned historically in the lower reaches of several tributaries to the Bonneville pool and along the Washington shoreline, this habitat was inundated by the Bonneville pool in 1938 (Fulton 1970). Although some adult chum salmon still pass Bonneville Dam (see below), the smolt monitoring program has no record of juvenile chum salmon passage at Bonneville Dam between 1985 and the present (Wood 2000). Thus, although the facts are uncertain, it is unlikely that more than a very small proportion of any year class is affected by project passage.

6.2.9.11.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River estuary and plume that in turn affect the growth and survival of subyearling CR chum salmon. However, the evidence for these relationships is largely inferential and is the subject of ongoing research.

6.2.9.11.4 Adult Migration Corridors

Water Quality/Water Quantity/Velocity/Cover/Shelter/Space. Adult CR chum salmon are late fall/early winter migrants. Biological requirements for water quality, quantity, velocity, cover, shelter, or space in the mainstem Columbia River adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. CR chum salmon do not have biological requirements for riparian vegetation or food in the adult migration corridor.

Migration Conditions. Adult chum salmon are known to show little persistence in surmounting river blockages and falls (63 FR 11775). The extent to which Bonneville Dam has acted as a barrier to upstream migration is unknown. The latest available full counts of chum salmon over Bonneville Dam are 195 and 135 adults during 1998 and 1999, respectively (Table C-12). There are no estimates of adult passage survival of CR chum salmon at Bonneville or any other FCRPS dam.

6.2.9.11.5 Spawning Areas. The Action Agencies can use reservoir storage from the upper Columbia and Snake river basins to augment mainstem flows below Bonneville Dam, creating access to and increasing the areal extent of spawning habitat in the Ives Island area. Under the proposed action, the likelihood of meeting a minimum spawning flow (125 kcfs at Bonneville Dam) during November and December is 90% or less (Table 6.2-5). Adult CR chum salmon do not have biological requirements for food, cover, shelter, or riparian vegetation associated with spawning habitat. FCRPS reservoir storage does not affect temperatures in the Ives Island area during November and December, when chum salmon spawn.

6.2.9.12 Snake River Sockeye Salmon

6.2.9.12.1 Juvenile Rearing Areas. Juvenile SR sockeye salmon rear in rear in lakes in tributary systems to the Snake River and, therefore, do not have biological requirements for rearing habitat in the action area.

6.2.9.12.2 Juvenile Migration Corridors

Juvenile SR sockeye salmon are yearling migrants, with peak movement past Lower Granite Dam during May.

Water Quality. Effects of the proposed action on biological requirements for water quality in juvenile migration corridors are the same as those discussed for SR spring/summer chinook salmon in the mainstem Snake and Columbia river juvenile migration corridor (above).

Water Quantity/Velocity/Cover/Shelter. Under the proposed action, the likelihood of meeting or exceeding flow objectives at Lower Granite and McNary dams during the spring migration season (April, May, and June) is 68% or less (Table 6.2-5).

Riparian Vegetation. Yearling sockeye salmon migrants do not have biological requirements for riparian vegetation in the mainstem Snake and Columbia river migration corridor.

Food. NMFS is uncertain whether yearling sockeye salmon migrants have a biological requirement for food in the mainstem Snake and Columbia river migration corridor or, if food is required, whether the abundance or composition of the prey assemblage will be adversely affected by the proposed action.

Space. Biological requirements for space in the mainstem Snake and Columbia river migration corridor are not likely to be adversely affected by the proposed action.

Migration Conditions. An unknown proportion of the juvenile migration is transported from the Snake River collector projects. Studies at John Day and Wanapum dams with run-of-the-river unlisted UCR sockeye salmon found that the FGE of juvenile sockeye salmon was lower than that of spring chinook salmon or steelhead. If this finding also applies to the Snake River ESU, it is likely that a smaller proportion of the sockeye salmon outmigration is transported compared with that of spring/summer chinook salmon or steelhead. If transport rates are lower, it is likely that the total direct survival of this species is also less than that of other yearling migrants.

6.2.9.12.3 Areas for Growth and Development to Adulthood. Current FCRPS operations may have effects on rearing habitat in the Columbia River plume that in turn affect the growth and survival of yearling SR sockeye salmon. The evidence for these relationships is largely inferential, however, and is the subject of ongoing research.

6.2.9.12.4 Adult Migration Corridors

Water Quality/Quantity/Velocity. Effects of the proposed action on biological requirements for water quality, quantity, and velocity in the mainstem Columbia and Snake river adult migration corridor are the same as those for SR spring/summer chinook salmon (above).

Cover/Shelter/Space. Biological requirements for cover, shelter, and space in the adult migration corridor are not likely to be adversely affected by the proposed action.

Riparian Vegetation/Food. Adult SR sockeye salmon do not have biological requirements for riparian vegetation or food in the mainstem Columbia and Snake river migration corridor.

Migration Conditions. Because few adult sockeye salmon have returned to the Snake River basin in recent years, little information has been collected on their survival through mainstem FCRPS projects. Tagging studies using adult sockeye salmon from the unlisted Upper Columbia River ESU measured an average per-project survival of 98% through the lower Columbia River. Expanding the per-project rate over the 8-project (Bonneville to Lower Granite) reach, NMFS estimates an adult survival rate of 86% for this ESU (Table 6.1-1).

6.2.9.12.5 Spawning Areas. SR sockeye salmon spawn in tributary systems to the mainstem Columbia River and do not have biological requirements for spawning habitat in the action area.

6.3 ANALYSIS OF EFFECTS OF PROPOSED ACTION ON BIOLOGICAL REQUIREMENTS OVER FULL LIFE CYCLE

Appendix C describes the median annual population growth rate (lambda) and the risk of absolute extinction at the ESU and, in some cases, the population level. In this section, NMFS examines the likely effects of the proposed action on the risk of extinction and the likelihood of recovery (Section 1.3.1.1 and 6.1.2). Although the jeopardy standard is ultimately a qualitative assessment of whether there is a high likelihood of survival with an adequate potential for recovery, NMFS considers the specific level of improvement needed to achieve particular risk levels as one indication of population status relative to that jeopardy standard (Sections 1.3.1.1 and 6.1.2). These risk levels (≤5% risk of extinction in 24 and 100 years; ≥50% likelihood of meeting interim recovery abundance levels in 48 and 100 years; ≥50% likelihood that population growth rate will be stable or increasing) are referred to subsequently as "survival indicator criteria" or "recovery indicator criteria." This standardized analysis is used to evaluate the importance of the effects described in the preceding section as likely to occur in the action area in the context of the full life cycle. The data for some of the ESUs considered in this biological opinion are too scarce or of inadequate quality to permit a quantitative life-cycle analysis of this type. For some of those ESUs, inferences can be drawn from the quantitative results described for the other ESUs.

Details of the quantitative analyses used to evaluate the effects of the proposed action on biological requirements over the full life cycle are described in Section 6.1.2 and Appendix A. Quantitative and qualitative estimates are summarized for several ESUs in the following sections.

6.3.1 Snake River Spring/Summer Chinook Salmon

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range, including habitat degradation in many areas due to timber harvest, grazing, and mining practices (loss of pools, high temperatures, low flows, poor overwintering conditions, and high sediment loads).

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

6.3.1.1 Populations Evaluated

NMFS evaluated 43 spawning aggregations of SR spring/summer chinook salmon. Seven of these are the index stocks described in the June 27, 2000, draft biological opinion, previous NMFS analyses (McClure et al. 2000b), and PATH reports (Marmorek et al. 1998). The remaining spawning aggregations were the subject of new analyses in McClure et al. (2000c). NMFS has not yet determined which, if any, of the index stocks and additional spawning aggregations represent "populations," as defined by McElhany et al. (2000), but all are treated as independent populations because of the statistical assumptions inherent in the analysis.

6.3.1.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from the base period lambda necessary to achieve $\geq$50% likelihood of meeting interim recovery abundance levels (NMFS 1995c) in 48 and 100 years using the most current estimates of lambda and methods described in Appendix A. Interim recovery abundance levels have been defined only for three ESUs and, in the SR spring/summer chinook ESU, only for the seven index stocks. Therefore, NMFS estimated the change in lambda necessary to meet an alternative recovery indicator criterion of lambda $\geq$1.0 (Appendix A) for all other spawning aggregations. Details of each of these estimates are included in Appendix A.

NMFS also investigated the effects of adding preliminary returns in 2000 and an estimate of expected returns in 2001 (based on jack abundance) to the time-series used to estimate lambda in each of the calculations described above. Estimates are included in McClure (2000b). These preliminary returns were included in the lowest estimates of necessary survival changes.

6.3.1.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from 1980 to 1999 will continue indefinitely into the future. However, the juvenile SR spring/summer chinook salmon survival rate associated with the proposed action represents an improvement from the average survival rate influencing base period adult returns. That is because many structural and operational modifications to the hydrosystem have been implemented since 1980. Juvenile bypass systems were installed at McNary Dam in the early 1980s, at both Bonneville Dam powerhouses and at John Day Dam in the mid-1980s, and at Lower Monumental and Ice Harbor dams in the early 1990s. Juvenile bypass systems were also upgraded at Little Goose and McNary dams in the early 1990s, extended-length intake screens that increase guidance away from turbines were installed in bypasses at three projects in the late 1990s, and the Bonneville Second Powerhouse bypass was upgraded at the end of the 1990s. Bypass systems at Lower Granite, Little Goose, Lower Monumental, and McNary (through 1994) dams have allowed juvenile transportation from those projects, increasing the proportion of smolts transported over the base period and increasing the corresponding direct juvenile survival rate.

Spill rates also increased during the period, improving the survival of inriver migrants. The 1989 spill agreement provided spill to ensure that 70% of spring migrants and 50% of summer migrants passed each project without going through turbines. The 1995 FCRPS Biological Opinion established spill levels equivalent to 80% of both spring and summer migrants passing a project without going through turbines, unless dissolved gas caps prevented it. Flow deflectors were installed at Ice Harbor and John Day dams in the mid-1990s, reducing TDG levels and permitting additional spill. Since the mid-1990s, NMFS has required that turbines be operated within 1% of peak efficiency to improve the survival of fish passing through turbines.

During the same period, flow augmentation also increased to improve survival of inriver migrants. The NWPPC water budget was established during the 1983 migration season. It consisted of a program for spring flow augmentation using a volume approach. No summer flow augmentation was established. In 1992 and 1993, the volumes available for flow augmentation were increased and summer flow augmentation was established. The 1995 FCRPS Biological Opinion established spring and summer target flows and identified additional storage volumes to increase the likelihood of meeting the targets. Although these changes to the hydropower corridor have been made since 1980, the period chosen for the analysis of extinction risk does not include the extremely large and one-time impacts of dam construction.

NMFS used two methods to estimate the proportional change in juvenile survival from that experienced on average by adults returning from 1980 to 1999 to that associated with the proposed action. The first method compared PATH estimates of juvenile survival during 1980 to 1992 (retrospective scenario of Marmorek et al. 1998) to PATH estimates of 1995 FCRPS Biological Opinion operations applied to the same water conditions (scenario A2 of Marmorek et al. 1998). The purpose was to evaluate historical survival versus an approximation of current juvenile survival under a 13-year range of water conditions. NMFS applied the approach in response to comments by agencies and organizations that the method used in the July 27 draft biological opinion evaluated the change from historical to current operations under too narrow a range of water years for current operations, which led to overly optimistic results.

The 1980 juvenile passage survival corresponds to the first migration year that fully contributes to adult returns in the first pair of 5-year running sums used to calculate lambda (McClure et al. 2000c, Holmes [in review]). The 1992 migration year was the last available from the PATH analysis. The survival rate used in the NMFS' comparison included estimates of direct survival to below Bonneville Dam from both of PATH's alternative passage models and differential post-Bonneville survival of transported fish, as described in Section 6.2.3.3.1 (D = 0.63 to 0.73). NMFS included differential post-Bonneville survival (D) in the survival estimates because, even though NMFS finds no evidence that D changed between the two periods, different proportions of fish were transported over time. Because the proportion of transported fish surviving to Bonneville is multiplied by D, this leads to a significant impact of the D term. On the other hand, delayed mortality of nontransported fish had no effect on the proportional change in survival, so was not relevant to this analysis. The expected survival change ranged from 27% to 38%, depending on passage model and D assumption, and averaged 32% (1.32 times the average historical survival rate) across all assumptions.

The second method represented a modification of the approach used in the July 27 draft biological opinion. In this case, the historical period was defined using PATH passage model estimates for 1980 to 1992 and SIMPAS model estimates for 1994 to 1997. The 1980 juvenile passage survival was defined for the earliest year, for reasons described above. The 1997 smolt migration was the last migration year contributing to the 1999 adult returns in NMFS' 1980-to-1999 risk assessment. An estimate for 1993 is not available from either passage modeling system. The average of all 17 years was the estimate corresponding to NMFS' 1980-to-1999 risk assessment. NMFS defined current operations, corresponding to effects of the proposed action, as the 1994-to-1999 average SIMPAS estimates. Section 6.2 describes the rationale for equally weighting each year when calculating the average. This second method resulted in expected survival improvements ranging from 12% to 35%, depending upon passage model and D assumption, and averaged 24% (1.24 times the average historical survival rate) across all assumptions.

The July 27, 2000, draft biological opinion included a method similar to this second approach, since it also combined SIMPAS and PATH estimates of juvenile survival to evaluate the change in juvenile survival. Several agencies and organizations criticized that approach, claiming that some intrinsic difference between PATH and SIMPAS passage models overestimates the survival improvement associated with the proposed action. The difference cited most frequently was the treatment of reservoir survival in each passage model. However, both of PATH's passage models provide fairly close fits to NMFS' 1994-to-1996 PIT-tag reach survival estimates (Marmorek and Peters 1998), and the SIMPAS model is calibrated directly to those and to the 1997-to-1999 reach survival estimates (Appendix D). Additionally, both the structure and parameterization of the dam passage components of the SIMPAS model are very similar to those used in PATH (Appendix D). The main difference is that some of the parameter estimates used in SIMPAS reflect new information obtained since the PATH models were completed (Appendix D). Ideally, NMFS would compare PATH and SIMPAS estimates for the same years and actions to test the assumption that SIMPAS provides higher estimates of survival than PATH models. While this was possible for SR fall chinook results (see Section 6.3.3), there are no years for which both PATH and SIMPAS SR spring/summer chinook estimates exist. However, it is unlikely that significant discrepancies between PATH and SIMPAS exist because of the similar structure and similar fit to PIT-tag reach survival estimates, and because both the PATH-only and PATH/SIMPAS methods included in this analysis yield similar results. Also, because the method using both PATH and SIMPAS yields a lower estimate of the survival change than does the exclusive use of PATH estimates, this approach does not produce optimistic results compared with PATH.

No other quantifiable survival rates changed significantly between the average 1980-to-1999 and the current condition. For example, there is no evidence to suggest that adult survival through the hydrosystem has changed significantly under current operations, compared with average adult survival between 1980 and 1999. Current and future spring and summer chinook harvest rates are very similar to average harvest rates throughout the 1980-to-1999 period, so NMFS did not attempt to identify a change in survival associated with current harvest rates. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above Lower Granite Dam that may have resulted from habitat and hatchery management actions, so no change in those survival rates is included in this quantitative analysis. In Section 6.3.1.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.1.4 Additional Necessary Survival Changes

Table 6.3-1 shows the effect of the 24% to 32% survival rate increase expected from the proposed action on the future median annual population growth rates for 43 SR spring/summer chinook spawning aggregations. In some cases (e.g., Marsh Creek), the resulting population growth rate is expected to change from a declining trend (lambda <1.0) to a stable or increasing trend. In spite of the expected improvement in population growth rate, at least 22, and possibly as many as 27, of the 43 spawning aggregations require additional survival improvements to meet the survival and recovery indicator criteria. Table 6.3-1 displays the additional improvements in survival that would be necessary, beyond the 24% to 32% improvement associated with the proposed action, to reduce the 100-year extinction risk to 5% and either increase the likelihood of recovery in 48 years to 50% or increase the likelihood of achieving a stable or increasing population growth rate to 50%. These indicator criteria are presented because, if they are achieved, all the survival and recovery indicator criteria will be achieved.

Values in Table 6.3-1 less than or equal to 1.0 indicate that no further survival improvements are necessary to meet the survival and recovery indicator criteria. Values greater than 1.0 represent the multiplier by which survival would have to improve to achieve these criteria. For example, the survival change necessary to reduce the risk of extinction in 100 years to 5% (columns 8 and 9 of Table 6.3-1) is 0.89 to 1.10 for the Sulphur Creek index stock. This means that the proposed action, combined with expected survival in other life stages (see Section 6.3.1.6, below), is sufficient to reduce the 100-year extinction risk to 5% or less under the highest estimate of the expected survival change and the lowest estimate of the needed improvement. On the other hand, under the lowest estimate of the expected survival change and the highest estimate of the necessary survival change, an additional 10% survival improvement (1.10 times expected survival rate) is needed. This means that an additional 10% increase in egg-to-adult survival, or any component life-stage-specific survival rate, would be necessary to achieve no more than a 5% risk of extinction in 100 years for this index stock under the most pessimistic assumptions NMFS evaluated.

Table 6.3-1. Snake River spring/summer chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU Aggregate	0.82	0.91	1.24	1.32	0.86	0.97	1.53	1.63	1.17	1.98
Index Stocks:										
Bear Valley/Elk creeks	1.02	1.03	1.24	1.32	1.06	1.09	0.75	0.81	0.83	0.93
Imnaha River	0.88	0.92	1.24	1.32	0.92	0.98	0.88	1.21	1.32	1.74
Johnson Creek	1.01	1.03	1.24	1.32	1.06	1.10	0.76	0.81	0.73	0.87
Marsh Creek	0.99	1.00	1.24	1.32	1.03	1.06	0.77	0.93	1.02	1.17
Minam River	0.93	1.02	1.24	1.32	0.98	1.09	0.76	1.18	0.88	1.33
Poverty Flats	0.99	1.02	1.24	1.32	1.04	1.09	0.76	0.81	0.77	0.94
Sulphur Creek	1.04	1.05	1.24	1.32	1.09	1.12	0.89	1.10	0.81	0.91
Additional Aggregations:										
Alturas Lake Creek	0.75	0.75	1.24	1.32	0.78	0.79	N/A	N/A	2.81	3.00
American River	0.91	0.91	1.24	1.32	0.95	0.97	N/A	N/A	1.16	1.24
Big Sheep Creek	0.85	0.88	1.24	1.32	0.89	0.91	N/A	N/A	1.35	1.65
Beaver Creek	0.95	0.95	1.24	1.32	1.00	1.01	N/A	N/A	0.94	1.00
Bushy Fork	0.98	0.98	1.24	1.32	1.03	1.04	N/A	N/A	0.83	0.88
Camas Creek	0.92	0.92	1.24	1.32	0.97	0.98	N/A	N/A	1.09	1.16
Cape Horn Creek	1.05	1.05	1.24	1.32	1.10	1.12	N/A	N/A	0.60	0.64
Catherine Creek	0.78	0.85	1.24	1.32	0.82	0.83	N/A	N/A	1.57	2.41
Catherine Creek N. Fork	0.92	0.92	1.24	1.32	0.97	0.98	N/A	N/A	1.09	1.17
Catherine Creek S. Fork	0.80	0.80	1.24	1.32	0.83	0.85	N/A	N/A	2.10	2.24
Crooked Fork	1.00	1.00	1.24	1.32	1.05	1.06	N/A	N/A	0.76	0.81
Grande Ronde River	0.77	0.84	1.24	1.32	0.81	0.82	N/A	N/A	1.66	2.54
Knapp Creek	0.89	0.89	1.24	1.32	0.93	0.95	N/A	N/A	1.27	1.36
Lake Creek	1.06	1.06	1.24	1.32	1.11	1.13	N/A	N/A	0.59	0.63
Lemhi River	0.98	0.98	1.24	1.32	1.02	1.04	N/A	N/A	0.84	0.90
Lookingglass Creek	0.72	0.79	1.24	1.32	0.76	0.77	N/A	N/A	2.11	3.40
Loon Creek	1.00	1.00	1.24	1.32	1.05	1.07	N/A	N/A	0.74	0.79
Lostine Creek	0.87	0.90	1.24	1.32	0.91	0.93	N/A	N/A	1.20	1.50
Lower Salmon River	0.92	0.92	1.24	1.32	0.96	0.98	N/A	N/A	1.11	1.19
Lower Valley Creek	0.92	0.92	1.24	1.32	0.97	0.98	N/A	N/A	1.08	1.15
Moose Creek	0.94	0.94	1.24	1.32	0.99	1.00	N/A	N/A	0.98	1.04
Newsome Creek	1.03	1.03	1.24	1.32	1.08	1.09	N/A	N/A	0.67	0.72
Red River	0.91	0.91	1.24	1.32	0.95	0.97	N/A	N/A	1.16	1.23
Salmon River E. Fork	0.94	0.94	1.24	1.32	0.99	1.00	N/A	N/A	1.00	1.07
Salmon River S. Fork	1.06	1.06	1.24	1.32	1.11	1.13	N/A	N/A	0.58	0.62
Secesh River	0.98	0.98	1.24	1.32	1.02	1.04	N/A	N/A	0.84	0.90
Selway River	0.91	0.91	1.24	1.32	0.96	0.97	N/A	N/A	1.13	1.21
Sheep Creek	0.80	0.80	1.24	1.32	0.84	0.85	N/A	N/A	2.06	2.20
Upper Big Creek	0.97	0.97	1.24	1.32	1.02	1.03	N/A	N/A	0.88	0.93
Upper Salmon River	0.90	0.90	1.24	1.32	0.95	0.96	N/A	N/A	1.18	1.26
Upper Valley Creek	1.03	1.03	1.24	1.32	1.08	1.10	N/A	N/A	0.66	0.70
Wallowa Creek	0.86	0.86	1.24	1.32	0.90	0.92	N/A	N/A	1.48	1.58
Wenaha River	0.84	0.90	1.24	1.32	0.88	0.90	N/A	N/A	1.19	1.74
Whitecap Creek	0.90	0.90	1.24	1.32	0.95	0.96	N/A	N/A	1.19	1.27
Yankee Fork, Salmon R	0.88	0.88	1.24	1.32	0.93	0.94	N/A	N/A	1.32	1.41
W. Fork, Yankee Fork	0.99	0.99	1.24	1.32	1.04	1.05	N/A	N/A	0.79	0.85

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically, except for the Imnaha (50% as effective). For index stocks, it also includes preliminary 2000 and projected 2001 returns in time series used to estimate lambda.
[3] Low represents estimation of juvenile survival improvement based on a comparison of PATH retrospective and prospective (A2) results.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS results.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for index stocks) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate of the expected survival improvement.

Three of the seven index stocks require no additional survival changes beyond those expected under the proposed action to meet the survival and recovery indicator criteria. The other four index stocks require additional survival improvements ranging from 12% to 74%. For the additional spawning aggregations, data were insufficient for estimating extinction risk, and no interim recovery levels have yet been determined. For the spawning aggregations, the necessary survival change is that which will result in lambda of 1.0. Under all assumptions, 21 of the 36 spawning aggregations require additional survival changes, ranging from 9% to 240%. An additional two spawning aggregations need no additional survival change under the best-case assumptions that NMFS evaluated, but they need survival changes ranging between 4% and 7% under the worst-case assumptions. The remaining 13 spawning aggregations require no additional survival improvements under any of the assumptions evaluated.

These results are similar to those of PATH, with respect to the need for additional survival improvements after the proposed action is implemented, in order to meet approximations of the survival and recovery indicator metrics. The magnitude of the additional changes differs, however, between the two approaches and among different PATH reports. The PATH decision analysis (Marmorek et al. 1998) presents a more optimistic view than the NMFS analysis, while a PATH preliminary analysis of experimental management options (Peters and Marmorek 2000) estimates the need for larger survival increases than estimated in NMFS' analysis.

PATH evaluated two actions similar to the proposed action (A1 and A2) for the seven SR spring/summer chinook salmon index stocks (Marmorek et al. 1998). The mean likelihood of reaching recovery goals in 48 years was approximately 50% for A1 and slightly less than 50% for A2 for the sixth-worst of the seven index stocks. Using this PATH analysis, survival changes necessary to meet this goal appear to be relatively small compared with NMFS' estimates. In contrast, NMFS' analysis finds that a 0% to 33% survival increase is necessary for the sixth-worst stock[8] to achieve recovery within 48 years (Table 6.3-1). This more optimistic PATH analysis used a larger set of historical brood years (1950s through 1990s) and a broader set of assumptions for future conditions than the NMFS analysis.

A PATH analysis of experimental management options evaluated the risk of continuing the survival rates associated with only the 1978-to-1994 brood years into the future (Peters and Marmorek 2000). Under this set of assumptions, the PATH analysis was more pessimistic than NMFS' analysis. A 170% survival improvement would be necessary for the sixth-worst stock to achieve a 50% probability of recovery in 48 years. This PATH analysis did not consider the 24%-to-32% survival increase from average 1980 to the present survival (described in Section 6.3.1.3). Even if this survival improvement had been included in the PATH analysis, however, the estimated survival shortfall would still be greater than the shortfall estimated by the analysis in this biological opinion (Table 6.3.1.3). Both of these PATH analyses differ from NMFS' analysis in the time periods they considered. PATH models also included density dependence, which continually reduced productivity as stocks approach abundance levels near the recovery goal. In the case of Sulphur Creek, the sixth-worst stock in PATH's analysis, the maximum

[8] The sixth-worst stock is Marsh Creek under some assumptions, Minam River under others.

sustainable production was estimated at approximately 280 spawners (calculated from the slope of beta in Table 2 in Schaller et al. 1999), which is nearly identical to NMFS' interim recovery level (283 spawners).

PATH also estimated the probability of quasi-extinction (five fish per generation) in 100 years if 1978 to 1994 brood year survival continued (Peters and Marmorek 2000). The extinction risk ranged from 5.8% for the Imnaha index stock to 87.4% for the Marsh Creek stock. These estimates are comparable to NMFS' estimates of absolute extinction risk (0% to 100%, depending on index stock and hatchery-origin spawner effectiveness (McClure et al. 2000c). The improvements from the 1980-to-recent period described above should reduce extinction risk similarly for each model; however, the PATH model appears insensitive to changes in extinction risk with alternative management actions (Peters and Marmorek 2000).

PATH also evaluated the performance of these stocks relative to the 1995 FCRPS Biological Opinion's 24-year and 100-year survival metric (replaced with the extinction indicator criterion in the current analysis). The mean PATH results for the probability of being above the survival threshold were 65% over 24 years and 75% over 100 years (Marmorek et al. 1998). These estimates can be compared to 70%, which is a numerical approximation of the acceptable risk considered by NMFS in the 1995 FCRPS Biological Opinion. Thus, PATH determined that the A1 and A2 actions met an approximation of the acceptable level of risk over 100 years, but fell somewhat short of meeting that criterion over a 24-year period. The more pessimistic PATH experimental management report, which projected 1978-through-1994 brood year survivals into the future (Peters and Marmorek 2000), estimates that an additional 640% survival increase is needed for the worst index stock to meet the 24-year survival criterion and an additional 170% increase is necessary to meet the 100-year survival criterion. Estimates for the sixth-worst stock were more optimistic. As described above, this analysis did not apply the 24%-to-33% improvements from the survival of the 1980 through 1999 brood years. It does not appear, however, that inclusion of these improvements would significantly reduce the necessary additional survival improvement estimated by PATH.

6.3.1.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. The substantial comments primarily questioned the estimates of hydrosystem survival associated with the proposed action (addressed in Section 6.2), the method of estimating the expected proportional change in the juvenile survival rate from the average associated with base period returns (addressed above in one new and one modified method of estimating the expected change), the analytical assumption that all survival changes are achieved instantaneously, and the assumption that the effectiveness of hatchery-origin spawners may have been as low as 20% of that of wild-origin spawners.

Concerns about the implementation schedule were primarily directed at the RPA described in the July 27 draft biological opinion, which included actions not yet implemented. The analysis of the proposed action, however, as described above, is based on actions currently being implemented. Specifically, the juvenile survival rates through the hydrosystem are estimated from survival studies conducted between 1994 and 1999, and are not based on an expectation of future improvements. This criticism is, therefore, not relevant to the analysis of the proposed action.

In the July 27 draft biological opinion, NMFS evaluated actions under a 20%-to-80% range of assumptions regarding historical effectiveness of hatchery-origin natural spawners. NMFS concluded that the 80% assumption produced unrealistic results, so did not consider it when defining necessary survival improvements for the July 27 draft biological opinion's RPA. Many commenters disagreed with this conclusion. NMFS later determined that a computational error in the original CRI risk assessment was responsible for the unrealistic results, not the assumption of historical 80% hatchery-origin spawner effectiveness. NMFS therefore agrees with comments on this point and is considering results from the full 20%-to-80% range of assumptions in all analyses, unless specific information for a particular stock indicates that other assumptions are more appropriate.

Several agencies and organizations commented further that NMFS' 20%-to-80% range of historical effectiveness of hatchery-origin spawners was incorrect, and recommended that only the high end of this range should be applied to SR spring/summer chinook index stocks. Only ODFW included information to support this opinion. The information provided for the Imnaha River stock included a review of the wild fish supplementation effort on that tributary that was convincing to NMFS. Waples (2000a) suggested that it would be reasonable to use a range of 20%-to-80% relative reproductive success for hatchery fish in the biological opinion analysis for most stocks. It also suggested that, absent information to the contrary, it is reasonable to assume that values for local, nondomesticated supplementation stocks would fall in the upper half of the range. NMFS concludes that the Imnaha program falls into this category. From the start, it has been oriented toward helping (rather than replacing) natural production, and its monitoring program has been one of the best in the region. However, even the best-run hatchery program cannot avoid all genetic effects of fish culture, which are not zero even for a single generation. Furthermore, reproductive success in the first generation of naturally spawning hatchery fish can also be influenced by nongenetic fish culture effects. Even the most natural hatchery environment differs in many ways from the natural environment experienced by wild fish. All studies that have directly evaluated reproductive success of hatchery fish in the wild have found a significant reduction, even for programs with histories similar to that of the Imnaha. NMFS concludes, therefore, that a range of 50% to 80% is more reasonable for the Imnaha River index stock than 20% to 80%, a change the analysis described above reflects.

Oregon provided information on the effect of hatchery spawners on the Minam River index stock. NMFS did not find the arguments convincing. The Minam is (or was) a wild population not intended to be supplemented with hatchery fish, but that happened inadvertently through straying of the non-native Rapid River stock. Waples (2000a) suggested that, without information to the contrary, it might be reasonable to assume that the reproductive success of hatchery fish in this situation would be in the lower half of the 20%-to-80% range. Oregon argued that the Minam River stock could not have been adversely affected by hatchery straying because its spawner-to-Columbia-River-recruit survival index has shown a similar trend to that of the Marsh Creek index stock, which is not influenced by hatchery spawners. That analysis provides indirect evidence that the effectiveness of hatchery spawners may be relatively high. However, another indirect line of evidence is available from genetic data collected from parr. In the Minam, as well as in the Grande Ronde River, the Wenaha River, and Catherine Creek, NMFS found that samples from some years were genetically very similar to the Lookingglass Hatchery stock, while samples from other years were quite distinctive (Waples 2000b). These results have been presented in regional meetings, as well as to the Grande Ronde science panel convened in 1996 to evaluate using Lookinglass Hatchery fish in the basin.

There is no strong correlation between estimated stray rate and degree of genetic similarity in the yearly samples. A possible explanation is that reproductive success of the stray hatchery fish was quite variable, being high in some years and low in others. Other possible explanations are high sampling variance in the genetic data or estimates of stray rate. Population allele frequencies vary considerably year to year as a result of drift in these small populations, but this random process should not produce a series of years in which the similarity to Lookingglass Hatchery stock is high. In summary, available information is equivocal regarding the reproductive success of stray hatchery fish in the Minam River. The data are consistent with the hypothesis that success is relatively high in at least some years, but it would not be prudent to assume that is the case in general. Therefore, NMFS continued to evaluate a 20%-to-80% range of hatchery effectiveness for the Minam River index stock in the analysis described above.

Most of the other SR spring/summer chinook index stocks are not affected by this assumption because hatchery-origin spawners are either absent or represent a small fraction of natural spawners. Substantive arguments or additional information were not received for these other stocks.

This analysis also contains assumptions that may make the results overly pessimistic. Three are the analytical assumptions that all spawning aggregates behave as independent populations; that all supplementation programs cease immediately; and that background survival will continue as it has from 1980 to the present.

NMFS assumed for its analysis that all spawning aggregates behave as independent populations. This assumption is unlikely, however, given the geographic proximity and demographic and genetic similarity of many of the spawning aggregates. Nevertheless, it is a conservative assumption in the absence of information about this ESU to the contrary. If a review by a technical recovery team defines the SR spring/summer chinook populations (as used by McElhany et al. 2000) as groups of two to several spawning aggregates, which would have higher combined abundance than the component spawning aggregates, the extinction risk analysis will indicate that smaller changes in survival are necessary to avoid extinction. The recovery analysis may or may not be more optimistic than the analysis described above, depending on the final recovery abundance levels and other recovery criteria. Until a thorough review of the population structure of this ESU is complete, NMFS has few options for addressing problems with this assumption. NMFS' primary response is to evaluate the jeopardy standard with an expectation that only 80% of available spawning aggregates must meet expected criteria.

A second assumption that leads to pessimistic results is the analytical focus on risk to wild fish. This approach is consistent with ESA precepts, which call for the evaluation of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. However, it discounts the short-term benefits (and for some ESUs, such as SR sockeye, the necessity) of hatchery programs. The analysis described above assumes that any ongoing supplementation programs stop immediately; the risk to the wild component of ESUs is based on this assumption. To the extent that current supplementation programs are reducing the extinction risk for wild fish, this effect is not included in the results of this analysis. Again, few options are available to NMFS to address the shortcomings of this assumption. A more complex modeling approach could be pursued, but it would be limited by uncertainty about how to quantify the benefits and negative impacts of ongoing supplementation programs. It would also require a variety of assumptions regarding the likely scope and duration of future hatchery programs. In short, there is little that NMFS can do to improve on this assumption in the quantitative analysis. However, the factor is considered qualitatively in reaching a jeopardy conclusion.

A third assumption that may lead to pessimistic results is the implicit assumption that climatic conditions and other background factors influencing survival will continue as they have, on average, between 1980 and the present. Coronado and Hilborn (1998a,b) and Deriso et al. (1996) compared trends in survival among salmonid stocks from a range of locations in the Pacific Northwest that experience varying degrees of anthropogenic effects. Both analyses indicated that most stocks experienced above-average survival for the early 1980s brood years, but that survival has generally been below average since about the 1983 brood year. The common survival trends among stocks are probably a result of large-scale stressors, such as ocean conditions (Francis and Hare 1994, Mantua et al. 1997, Hare et al. 1999). The analysis described above assumes that the generally poor conditions influencing 1980-to-1999 returns will continue indefinitely. However, preliminary estimates of return rates in 2000 are well above average, and some have hypothesized that ocean conditions may be shifting to a more favorable regime. NMFS investigated the effects of adding preliminary returns in 2000 and an estimate of expected returns in 2001 (based on 2000 jack abundance) to the time-series used to estimate lambda. This information was used to define the most optimistic results for this ESU. If recent high returns indicate a favorable shift in climatic conditions that will continue over several years, that additional reason for optimism is not captured in the analysis. However, NMFS does consider the possibility of an ongoing effect of favorable climate qualitatively in reaching a jeopardy conclusion.

6.3.1.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-1 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above the uppermost dam). The sufficiency of Federal survival and recovery measures to augment survival improvements resulting from the FCRPS proposed action is highly uncertain unless there can also be reliable progress on non-Federal survival and recovery measures in other life stages. The proposed action includes language that may be interpreted as a commitment by the Action Agencies to undertake or fund some of these non-Federal measures. The biological assessment is not explicit enough, however, to reach that conclusion with certainty. NMFS concludes that some proportion of the additional survival improvements identified in Table 6.3-1 may be achieved through ongoing Federal activities and through the proposed action. However, it is unlikely that the necessary improvements can be fully achieved because of the limited commitment to fund non-Federal habitat and hatchery improvements to offset hydrosystem impacts in the Action Agencies' biological assessment.

6.3.2 Snake River Fall Chinook Salmon

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Specifically, almost all the historical spawning habitat in the Snake River basin is blocked by the Hells Canyon Complex. Other irrigation and hydroelectric projects block access to habitat in tributaries to the Columbia River below Hells Canyon. Habitat quality is degraded by agricultural water withdrawals, grazing, vegetation management, and forestry and mining practices (lack of pools, high temperatures, low flows, poor overwintering conditions, and high sediment loads).

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

6.3.2.1 Populations Evaluated

NMFS analyzed the single aggregate Snake River fall chinook population. The analysis was based on Lower Granite Dam counts, so it does not include spawning areas in the Tucannon River and in the mainstem below some Corps dams.

6.3.2.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the aggregate population interim recovery abundance level (based on NMFS 1995c; specifics in Appendix A) in 48 and 100 years using the most current estimates of lambda and methods described in Appendix A.

6.3.2.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from the base period will continue indefinitely. However, the juvenile SR fall chinook salmon survival rate associated with the proposed action is an improvement over the average survival rate influencing base period adult returns. That is because of the many structural and operational modifications to the hydrosystem since 1980 (Section 6.3.1.3).

NMFS used two methods to estimate the proportional change in juvenile survival from that experienced on average by adults returning from 1980 to 1999 to that associated with the proposed action. The first method compared PATH estimates of juvenile survival for the 1976-to-1992 migration years (retrospective scenario of Marmorek et al. 1998) with PATH estimates of 1995 FCRPS Biological Opinion operations applied to the same water conditions (scenario A2 of Marmorek et al. 1998). The rationale and general method were identical to those defining the first method for SR spring/summer chinook salmon (Section 6.3.1.3). However, NMFS included an estimate of differential delayed mortality specific to SR fall chinook salmon (D = 0.24, Section 6.2.3.3) and used all available PATH retrospective juvenile survival estimates corresponding to base period adult returns. The expected survival change using this method ranged from -2% to +31%, depending on the PATH passage model, and averaged 15% (1.15 times the average historical survival rate).

The second method defined the historical period using PATH passage models, as described above. NMFS did not supplement the historical PATH estimates with SIMPAS passage survival estimates, as in the second method used for SR spring/summer chinook salmon (Section 6.3.1.3) because the first available SIMPAS estimate for fall chinook was the 1995 migration year, and those fish would not return as adults until at least 1997. NMFS defined current operations, corresponding to effects of the proposed action, as the 1995-to-1999 average SIMPAS estimates. Section 6.2 describes the rationale for equally weighting each year when calculating the average. The second method resulted in expected survival improvements ranging from -7% to +40%, depending on the PATH passage model, and averaged 16% (1.16 times the average historical survival rate) across all assumptions.

The second approach was similar to that included in the July 27, 2000, draft biological opinion, which also compared estimates of current operations, based on SIMPAS, to PATH estimates of historical juvenile survival. Several agencies and organizations criticized that approach, as described for SR spring/summer chinook salmon in Section 6.3.1.3. Reservoir survival in PATH's Columbia River Salmon Passage (CRiSP) passage model is directly calibrated to NMFS' 1995-to-1998 PIT-tag reach survival estimates (Peters et al. 1999), as is SIMPAS (Appendix D). PATH's Fish Leaving Under Several Hypotheses (FLUSH) model is not directly calibrated to this data (Peters et al. 1999). However, Figures 4.3.2-4 and 4.3.3-6 of Peters et al. (1999) suggest that the FLUSH model corresponds to the PIT-tag survival estimates, which are highly variable, about as well as the CRiSP model does.

In addition, both the structure and parameterization of the dam passage components of the SIMPAS model are very similar to those used in PATH (Appendix D). The main difference is that some of the parameter estimates used in SIMPAS reflect new information obtained since the PATH models were completed (Appendix D). NMFS compared total juvenile survival (including D = 0.24) estimates generated by the PATH FLUSH model and by SIMPAS for the 1995-through-1998 migration years. In each case, the estimates varied by no more than 3% and averaged 0.5% (Appendix A). CRiSP estimates developed for PATH ended in 1992, so it was not possible to conduct a similar comparison. However, significant discrepancies between PATH and SIMPAS are unlikely, because of the similar structure and similar fit to PIT-tag reach survival estimates, and because both the PATH-only and PATH/SIMPAS methods in this analysis yield similar results.

In addition to the change in juvenile passage survival, harvest rates changed significantly during this period. NMFS used two methods to evaluate the reduction in harvest from the 1980-to-1996 return year average. The first method is similar to that used in the July 27, 2000, draft biological opinion, which relies on PATH estimates of age-specific ocean exploitation rates and inriver exploitation rates (Peters et al. 1999). However, three changes were made in response to comments. First, the Pacific Salmon Commission (PSC) age-specific ocean natural survival rates were used in place of the constant natural survival rate assumed in the July 27 analysis. Second, the PSC maturation rates were used in preference to the CRI "propensity to reproduce" (bx) estimates in the earlier analysis, because of their greater consistency with the methods used by PATH. The modifications produced minor changes in the analysis. The third change (defining the current and future harvest rates as 70% of the 1988-to-1993 ocean and inriver harvest rates), however, reduced the expected survival improvement from that estimated previously. The modified definition of current and future harvest rates is more consistent with the Basinwide Recovery Strategy and with recent NMFS biological opinions on fall chinook harvest than is the previous definition (average 1993-to-1996 harvest rates). Using this approach, NMFS estimates that the reduction in ocean harvest rates has resulted in a 6% survival improvement, that the reduction in inriver harvest has resulted in a 9% survival improvement, and that the combination has resulted in a 16% survival improvement.

NMFS used a second method to estimate the reduction in harvest, to address comments by CRITFC and others that the PATH-derived harvest estimates in the July 27 draft did not match the estimates used by harvest management entities and by NMFS in its harvest biological opinions. Commenters did not question the validity of the PATH estimates, which are based on CWT cohort survival estimates, but suggested that the estimates be reconciled with the PSC and *U.S. v. Oregon* Technical Advisory Committee harvest rate estimates. NMFS was unable to reconcile the estimates, but concluded that there are advantages and disadvantages of both the PATH approach and the harvest modeling approach used by PSC and the Technical Advisory Committee. Therefore, NMFS includes estimates derived from both approaches in this analysis.

The second method relies on results of a PSC model run (Simmons 2000) that expresses combined ocean and inriver harvest as losses of age-3 to -5 adult equivalents to the mouth of the Columbia River. NMFS compared average 1980-to-1996 adult equivalent exploitation rates to 70% of average 1988-to-1993 adult equivalent exploitation rates. The estimated survival change using this second method was 40%.

The four combinations of the two alternative harvest change methods and the two alternative juvenile survival change methods result in estimates of total survival change ranging from 31% to 63% (1.31 to 1.63 times the average historical survival rate).

No other quantifiable survival rates changed significantly between the average 1980-to-1999 and the current condition. For example, there is no evidence to suggest that adult passage survival through the hydrosystem has changed significantly under current operations, compared with average adult survival between 1980 and 1999. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above Lower Granite Dam that may have resulted from habitat and hatchery management actions. Therefore, no change in those survival rates is included in this quantitative analysis. In Section 6.3.2.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.2.4 Additional Necessary Survival Changes

Table 6.3-2 shows the effect of the 31%-to-63% increase in survival rate expected from the proposed action on the future median annual population growth rates for the aggregate SR fall chinook population. The resulting population growth rate is expected to change from a declining trend (lambda <1.0) to a stable or increasing trend (lambda = 1.03) under the highest estimate of survival change. Under the lowest estimate of improved survival, however, the population growth rate is still expected to decline. In both cases, an additional improvement of from 6% to 64% is needed to meet the recovery indicator criteria.

The results of the NMFS SR fall chinook analysis for the proposed action are generally consistent with the PATH assessments of a similar action. Both assessments indicate that no additional survival changes are needed to meet alternative survival indicator criteria, given similar assumptions regarding annual climate/environmental variability, harvest rates, and differential mortality for transported smolts. However, both assessments indicate that additional survival improvements would be required to meet the 48-year recovery indicator criterion.

PATH evaluated an action (A2) that incorporated most of the elements of the proposed action with respect to SR fall chinook (Peters et al. 1999). The action A2 incorporated the changes in hydropower operations called for in the 1995 FCRPS Biological Opinion. PATH evaluated actions under a range of assumptions regarding post-Bonneville Dam differential delayed mortality of transported fish relative to nontransported fish (expressed as a differential survival factor D). The ability of action A2 to meet PATH survival and recovery criteria depended on the assumption regarding D. If D is relatively high or if it had improved substantially over base values, PATH projected that A2 would readily exceed survival and recovery criteria used in the assessments. Under the assumption that D has remained at approximately 20%, approximating the level used in the current NMFS analysis (see Section 6.2.3.3), action A2 was projected to meet survival criteria but to fall short of recovery targets. Specifically, the PATH analysis projected the mean likelihood of reaching recovery goals in 48 years as 34%, 16 percentage points below the 50% likelihood associated with the recovery indicator criterion.

Table 6.3-2. Snake River fall chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
SR fall chinook aggregate	0.87	0.92	1.31	1.63	0.93	1.03	0.75	1.07	1.06	1.64

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents estimation of juvenile survival improvement based on PATH retrospective and prospective (A2) results and change in harvest rate based on PATH.
[4] High represents estimation of juvenile survival improvement based on a combination of PATH and SIMPAS and harvest rate change based on PSC modeling.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

6.3.2.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to SR fall chinook salmon, but many of the points raised for SR spring/summer chinook salmon may also apply to SR fall chinook salmon. Substantial comments primarily questioned the estimates of hydrosystem survival associated with the proposed action (addressed in Section 6.2); the method of estimating the expected proportional change in the juvenile survival rate from the average associated with base period returns (addressed above in one new and one modified method of estimating the expected change); the method of estimating the change in harvest rate (addressed above in one new and one modified method); the analytical assumption that all survival changes are achieved instantaneously; and the assumption that the effectiveness of hatchery-origin spawners may have been as low as 20% that of wild-origin spawners.

Concerns about the implementation schedule were directed primarily at the RPA in the July 27 draft biological opinion, which included actions not yet implemented. However, the analysis of the proposed action, as described above, is based on actions (including reduced harvest) currently being implemented. Therefore, this criticism is not relevant to the analysis of the proposed action.

As described in Section 6.3.1.5 for SR spring/summer chinook, NMFS agrees that the full 20%-to-80% range of assumptions regarding historical effectiveness of hatchery-origin natural spawners should be included in the analysis and in NMFS' conclusions. No comments were received suggesting that any range other than 20% to 80% should be applied to SR fall chinook salmon.

This analysis also contains assumptions that may make the results overly pessimistic. Two such assumptions are that all supplementation programs cease immediately and that background survival will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. To the extent that current supplementation programs reduce the short-term extinction risk for wild fish, however, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climatic conditions and other background factors influencing survival have been below average for most of the period included in this analysis. Assuming that climatic conditions and other background factors influencing survival will continue as they have, on average, during the years influencing 1980-through-1996 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. Some preliminary information suggests that this may be the case for SR fall chinook. Table C-5 of Appendix C indicates that wild adult returns to lower Granite Dam in 1997 and 1999 were higher than estimates of escapement in any year between 1980 and 1996, while 1998 was one of the lowest wild escapements of that period. While these estimates were not calculated in the same manner as the estimates of escapements used in the analysis described above, they roughly indicate improving survival in recent years. NMFS does not rely on the expectation of improving ocean and other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.2.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-2 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above the uppermost dam). The sufficiency of Federal survival and recovery measures to augment survival improvements resulting from the FCRPS proposed action is highly uncertain unless there can also be reliable progress on non-Federal survival and recovery measures in other life stages. The proposed action includes language that may be interpreted as a commitment by the Action Agencies to undertake or fund some of these non-Federal measures. The biological assessment is not explicit enough, however, to reach that conclusion with certainty. NMFS concludes that some proportion of the additional survival improvements identified in Table 6.3-2 may be achieved through ongoing Federal activities and through the proposed action. However, it is unlikely that the necessary improvements can be fully achieved because of the limited commitment to fund non-Federal habitat and hatchery improvements to offset hydrosystem impacts in the Action Agencies' biological assessment.

6.3.3 Upper Columbia River Spring Chinook Salmon

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of UCR spring chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and

Appendix C) limits this ESU over its full range. Chief Joseph and Grand Coulee dams prevent access to historical spawning grounds farther upstream. Local problems relate to irrigation diversions and hydroelectric development, as well as riparian and instream habitat degraded from urbanization and livestock grazing along riparian corridors.

In this section, NMFS quantitatively evaluates action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

6.3.3.1 Populations Evaluated

NMFS analyzed the three populations identified by Ford et al. (1999) as components of this ESU: the Wenatchee River population, the Methow River population, and the Entiat River population. Ford et al. (1999) identified interim recovery goals for each population and included the criterion that all three must meet these goals for delisting.

6.3.3.2 Necessary Survival Change

McClure et al. (2000b,c) and Cooney (2000) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. Cooney (2000) and NMFS (Appendix A) also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the three population interim recovery abundance levels (Ford et al. 1999) in 48 and 100 years using the most current estimates of lambda and methods described in Appendix A. The CRI analytical approach (McClure et al. 2000b) and the QAR analytical approach (Cooney 2000) produce different estimates of necessary survival changes for these populations. NMFS considers both approaches to have advantages and disadvantages and uses results from both to define a range of necessary survival change.

NMFS also investigated the effects of adding 1999-to-2000 preliminary and 2001 projected returns to the time-series used to estimate lambda in each of the calculations described above. The 2001 projections are based on recent jack counts. Estimates are included in McClure et al. (2000b) and Cooney (2000). The preliminary estimates are included in the lowest estimates of necessary survival changes.

6.3.3.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from 1980 to 1998 will continue indefinitely. However, the Basinwide Recovery Strategy identifies implementation of the Mid-Columbia Habitat Conservation Plan (HCP) at five PUD projects as a probable element of recovery planning that is, therefore, included in the analysis, consistent with step 4 of the jeopardy analysis framework described in Section 1.3. The Basinwide Recovery Strategy estimates that this action will be implemented within 2 to 5 years. Cooney (2000, Table 20) estimates that implementing the HCP will improve survival by 28% for the Wenatchee population, 40% for the Entiat population, and 49% for the Methow population.

NMFS estimates that juvenile survival from McNary Dam to Bonneville Dam has changed from the average survival rate affecting adult returns in 1980 through 1998 because transportation from McNary Dam has discontinued, and because structural and operational modifications to the four lower Columbia River dams have been implemented since 1980 (Section 6.3.1.3). The project modifications have improved survival for inriver migrants, but the system survival from McNary Dam to Bonneville has declined from the average rate during the base period, when a significant proportion of the smolts were transported (Cooney 2000; Appendix A). The proposed action specifies that nearly all fish must remain in the river because of very low returns of transported smolts in 1994, after the new McNary bypass system was constructed (Appendix B to 1998 FCRPS Biological Opinion).

The size of the estimated decline in McNary-Bonneville juvenile survival depends on the estimate of historical differential post-Bonneville survival (D; see Section 6.2.3.3) during the years when smolts were transported from McNary Dam. NMFS evaluated D estimates ranging from 0.8 to 1.0, based on results of historical McNary transportation studies (Cooney et al. 2000; reviewed in NMFS 2000i). Only a fraction of the run is transported for the proposed action, so estimating D under the proposed action is not necessary for this ESU. Cooney (2000, Table 23) estimated 1980-to-1994 juvenile survival from McNary to Bonneville at 60.7% and 69.0% for historical D estimates of 0.8 and 1.0, respectively. These historical survival estimates are higher than the SIMPAS McNary-to-Bonneville survival estimates from 1994 to 1999, which averaged 57.5%. The resulting change in lower river survival associated with the proposed action was -5% (D = 0.8) to -17% (D = 1.0).

Combining changes in survival resulting from implementation of the Mid-Columbia HCP and modifications to the four lower Columbia River FCRPS projects results in a 7% to 41% increase in survival, depending on the population under consideration and the historical D estimate (Table 6.3-3; Appendix A).

No other quantifiable survival rates changed significantly between that affecting base period adult returns and the current and expected future condition. For example, there is no evidence to suggest that adult passage survival through the hydrosystem has changed significantly under current operations, compared with average adult survival between 1980 and 1998. Harvest rates also did not change significantly during that period. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival (other than those expected from the HCP), estuary survival, and adult survival above the upper dam that may have resulted from habitat and hatchery management actions, so no change in those survival rates is included in this quantitative analysis. In Section 6.3.3.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.3.4 Additional Necessary Survival Changes

Table 6.3-3 shows the effect of the 7%-to-41% survival rate increase expected from the proposed action on the future median annual population growth rates for the three UCR spring chinook populations. These effects vary according to whether the QAR analytical approach (Cooney 2000) or the CRI analytical approach (McClure et al. 2000c) is used to estimate the current population growth rate and the necessary change. Both the CRI and the QAR approaches indicate that the population growth rate will continue to be negative for all three populations after HCP implementation and continuation of the proposed action. On the basis of CRI estimates of the current population growth rate, additional survival improvements ranging from 55% to 226% (1.55 to 3.26 times the average base period survival rate) will be necessary to meet the recovery indicator criteria. On the basis of QAR estimates, additional survival improvements ranging from 45% to 153% (1.45 to 2.53 times the average base period survival rate) will be necessary to meet the recovery indicator criteria.

Table 6.3-3. Upper Columbia River spring chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

							Additional Change In Survival Needed to Achieve:			
Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU aggregate - CRI	0.84	0.85	1.16	1.32	0.86	0.90	1.40	1.65	1.55	1.86
Methow River - QAR	0.92	0.90	1.24	1.41	0.94	0.97	0.94	1.06	1.45	1.65
Entiat River - QAR	0.89	0.89	1.17	1.33	0.92	0.95	1.18	1.35	1.60	1.82
Wenatchee R. - QAR	0.88	0.92	1.07	1.21	0.89	0.96	1.16	1.64	1.77	2.53
Methow River - CRI	0.85	0.90	1.24	1.41	0.89	0.97	1.51	1.94	1.55	2.23
Entiat River - CRI	0.81	0.89	1.17	1.33	0.84	0.95	1.15	1.95	1.54	2.56
Wenatchee R. - CRI	0.80	0.85	1.07	1.21	0.81	0.89	1.43	2.14	2.15	3.26

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically and inclusion of preliminary and projected returns through 2001 for CRI estimates.
[3] Low represents an estimate of juvenile survival improvement based on assumption of historical D=0.8 from McNary Dam.
[4] High represents an estimate of juvenile survival improvement based on assumption of historical D=1.0 from McNary Dam.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A, including preliminary 2000 and projected 2001 returns for all except Methow QAR and Entiat QAR) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A, including only final returns through 1999) divided by the low estimate of the expected survival improvement.

6.3.3.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to, or in some cases relevant to, UCR spring chinook salmon. Three comments of particular relevance, however, were that NMFS should not assume that the Mid-Columbia HCP will be implemented and achieve its survival goals within the time described in the Basinwide Recovery Strategy; that the analysis is overly optimistic because it assumes that all survival changes are achieved instantaneously; and that the analysis is overly optimistic because NMFS rejected the assumption of 80% effectiveness of hatchery-origin natural spawners.

The first two comments apply to implementation of the HCP because it is the only future survival improvement anticipated in the analysis. CRITFC believes that anticipated HCP survival rates will not be achieved at all five PUD dams for at least 10 years because long-term gas-abatement projects are needed to achieve the necessary spill levels. NMFS agrees that there is some uncertainty about the exact schedule for achieving all survival improvements anticipated in the HCP, but the proposed HCP for the Chelan and Douglas PUDs and the draft EIS anticipate that the survival improvements will be achieved by the end of Phase I (2003). If this does not occur, it is reasonable to anticipate additional changes under the terms of the proposed HCP. Regardless of the exact implementation schedule, the analysis described above does assume that HCP survival improvements are achieved immediately, which is not the case. NMFS conducted a sensitivity analysis on the effect of a 10-year delay in implementing *any* survival improvements over the 1980-to-1998 average survival rate (Appendix C). Under this worst-case scenario, the CRI estimate of necessary survival change for the Wenatchee population increases from the estimate in Table 6.3-3 (additional 116% to 226% change) to a 265% to 368% change (Appendix A). This extreme scenario is unlikely, since some improvements associated with the HCP have already been achieved, but NMFS considers the implications of delayed implementation qualitatively in reaching jeopardy conclusions for this ESU.

As described in Section 6.3.1.5 for SR spring/summer chinook, NMFS agrees that the full 20%-to-80% range of assumptions regarding the historical effectiveness of hatchery-origin natural spawners should be included in the analysis and in NMFS' conclusions. The results described above reflect that range. No comments were received to suggest that any range other than 20% to 80% should be applied to UCR spring chinook salmon.

This analysis also contains assumptions that may make the results overly pessimistic. Two such assumptions are that all supplementation programs cease immediately, and that background survival will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative effects of hatchery programs. To the extent that current supplementation programs reduce the short-term extinction risk for wild fish, however, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climatic conditions and other background factors influencing survival have been below average for most of the period included in this analysis. The assumption that climatic conditions and other background factors influencing survival will continue as they have, on average, during the years influencing 1980-through-1998 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. Preliminary estimates of return rates in 2000 are well above average, and some hypothesize that ocean conditions may be shifting to a more favorable regime. NMFS investigated the effects of adding preliminary returns in 2000 and an estimate of expected returns in 2001 (based on 2000 jack abundance) to the time-series used to estimate lambda. This information was used to define the most optimistic results for this ESU. If recent high returns indicate a favorable shift in climatic conditions that will continue over several years, that additional reason for optimism is not captured in the quantitative analysis. However, NMFS does consider the possibility of an ongoing effect of favorable climate qualitatively in reaching a jeopardy conclusion.

6.3.3.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management, other than effects anticipated in the HCP. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-3 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above the uppermost dam). The sufficiency of Federal survival and recovery measures to augment survival improvements resulting from the FCRPS proposed action is highly uncertain unless there can also be reliable progress on non-Federal survival and recovery measures in other life stages. The proposed action includes language that may be interpreted as a commitment by the Action Agencies to undertake or fund some of these non-Federal measures. The biological assessment is not explicit enough, however, to reach that conclusion with certainty. NMFS concludes that some proportion of the additional survival improvements identified in Table 6.3-3 may be achieved through ongoing Federal activities and through the proposed action. However, it is unlikely that the necessary improvements can be fully achieved because of the limited commitment to fund non-

Federal habitat and hatchery improvements to offset hydrosystem impacts in the Action Agencies' biological assessment.

6.3.4 Upper Willamette River Chinook Salmon

Evaluation of the species-level effects of the proposed action requires placing the action-area effects of the proposed action in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of UWR chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include the loss of habitat due inundation or blockages resulting from the construction of numerous tributary hydroelectric and irrigation facilities, and habitat degradation due to timber harvest, development (agricultural, municipal, and industrial), dam development, and river channelization and dredging. Many of these activities result in poor water quality, high sediment loads, altered thermal regimes, and a large reduction in available spawning and rearing habitat.

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions could increase annual population growth rates such that survival and recovery are likely. Because UWR chinook salmon do not migrate past any mainstem dams on the lower Columbia River, NMFS has not estimated total system survival under the proposed action for this ESU.

6.3.4.1 Populations Evaluated

NMFS quantitatively evaluated one spawning aggregation, the McKenzie River above Leaburg Dam. Adequate information was not available for similar analyses for additional spawning aggregations. NMFS has not yet determined which, if any, of the UWR chinook spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the McKenzie River aggregation as an independent population satisfies the statistical assumptions inherent in the analysis.

6.3.4.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the McKenzie River spawning aggregation. NMFS also estimated the change from base period lambda necessary to achieve $\geq$50% likelihood of meeting the recovery indicator criterion of lambda $\geq$1.0 for this spawning aggregation. Details of these estimates are provided in Appendix A.

6.3.4.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for UWR chinook salmon, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. For this ESU, NMFS cannot identify any significant changes in survival rates under current or expected future conditions compared with those that influenced the base period adult returns. Survival changes due to implementing the proposed action can be quantified only for species that migrate past mainstem dams, which excludes UWR chinook salmon. NMFS was unable to quantify potential changes in egg-to-smolt survival, estuary survival, or adult survival that may have resulted from recent or ongoing habitat and hatchery management actions. In Section 6.3.4.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.4.4 Additional Necessary Survival Changes

Table 6.3-4 shows that the proposed action is not expected to increase the population survival rate; a negative median annual population growth rate is expected to continue for the UWR chinook spawning aggregation in the McKenzie River above Leaburg Dam. An additional survival improvement of from 9% to 65% (1.09 to 1.65 times the average base period survival rate) is needed to meet the extinction indicator criteria.

Table 6.3-4. Upper Willamette River chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

							Additional Change In Survival Needed to Achieve:			
Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
McKenzie River above Leaburg Dam	0.90	0.99	1.00	1.00	0.90	0.99	1.09	1.65	1.05	1.59

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

6.3.4.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations noted that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the proposed action would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, UWR chinook salmon. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately, and that the background survival rate will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. To the extent that current supplementation programs reduce the short-term extinction risk for wild fish, however, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climate and other background factors influencing survival have been below average for most of the period included in this analysis. Assuming that these factors will continue as they have, on average, during the years influencing 1980-through-1998 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. NMFS does not rely on the expectation of improving ocean and other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.4.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the proposed action on survival below Bonneville Dam, or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-4 are likely to be achieved through recent or anticipated future actions that affect other life stages.

Current FCRPS operations do not affect mainstem spawning or rearing habitat for UWR chinook salmon, although flow regulation may affect critical habitat for rearing in the estuary and plume. Available evidence is inferential, however, and thus insufficient for concluding that the proposed action will appreciably diminish the capacity of estuary or plume habitat to meet the biological requirements of listed fish. Thus, it is unlikely that the FCRPS is currently limiting the survival of this ESU below Bonneville Dam or that the proposed action will change the population survival rate.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal and non-Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above Willamette Falls). The proposed action, along with the future recovery efforts in the habitat and hatchery sectors anticipated in the Basinwide Recovery Strategy, is expected to be sufficient to meet survival and recovery indicator criteria.

6.3.5 Lower Columbia River Chinook Salmon

Evaluation of the species-level effects of the proposed action requires placing the action-area effects of the proposed action in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of LCR chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include the impacts of timber harvest (altered riparian vegetation, unstable streambanks, and decreased habitat complexity), agricultural practices (channelization and loss of riparian vegetation), road construction, and urban and industrial development; dams on the Cowlitz, Lewis, (Big) White Salmon, Clackamas, Sandy, and Hood rivers, which block fish passage to historical spawning areas; residual effects of mudflows from the Mt. St. Helens eruption (1980), which significantly disrupted and degraded habitat in the South Fork Toutle and Green rivers – as did post-eruption dredging, diking, and bank protection works in the Cowlitz River (below its confluence with the Toutle River); hatchery programs, beginning in the 1870s, which released billions of fish, homogenizing stocks between subbasins and introducing others from outside the ESU such that most of the fall-run chinook salmon spawning today in the Lower Columbia River ESU are first-generation hatchery strays; and an average total exploitation rate on fall-run stocks from this ESU of 65% for the base period brood years (approximately 45% in the ocean and 20% in freshwater).

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions could increase annual population growth rates such that survival and recovery are likely.

6.3.5.1 Populations Evaluated

NMFS quantitatively evaluated 20 spawning aggregations below Bonneville Dam. Adequate information was not available for similar analyses for spawning aggregations above Bonneville Dam. NMFS has not yet determined which, if any, of the LCR chinook salmon spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the 20 aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

6.3.5.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the 20 spawning aggregations of LCR chinook salmon. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the recovery indicator criterion of lambda ≥1.0 for each aggregation. Details of these estimates are provided in Appendix A.

6.3.5.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for the 20 spawning aggregations of LCR chinook salmon referenced above assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. Although structural and operational modifications have been made to Bonneville Dam since 1980, none of the spawning aggregations for which NMFS could perform quantitative analyses pass this project. Further, NMFS was unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 6.5.3.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

6.3.5.4 Additional Necessary Survival Changes

Table 6.3-5 shows that the proposed action is not expected to increase the survival rate of these 20 LCR chinook salmon spawning aggregations, all located below Bonneville Dam; negative median annual population growth rates are expected to continue. Survival improvements needed to meet the survival and recovery indicator criteria range from 3% to 732% (1.03 to 8.32 times the average base period survival rates). For the Lewis and Clark spawning aggregation, improvements of 934% to 1,493% (10.34 to 15.93 times the average base period survival rates) are needed.

Table 6.3-5. Lower Columbia River chinook estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

							Additional Change In Survival Needed to Achieve:			
Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
Aggregations Above Bonneville Dam										
(insufficient information for analysis)										
Aggregations Below Bonneville Dam										
Bear Creek	0.73	0.82	1.00	1.00	0.73	0.82	2.14	3.13	1.89	2.83
Big Creek	0.84	0.93	1.00	1.00	0.84	0.93	1.10	1.62	1.31	1.97
Clatskanie River	0.80	0.89	1.00	1.00	0.80	0.89	2.93	4.12	1.55	2.32
Cowlitz River tule	0.82	0.92	1.00	1.00	0.82	0.92			1.33	1.99
Elochoman River	0.88	0.99	1.00	1.00	0.88	0.99			1.04	1.56
Germany Creek	0.83	0.93	1.00	1.00	0.83	0.93			1.30	1.95
Gnat Creek	0.84	0.94	1.00	1.00	0.84	0.94	2.07	2.95	1.27	1.91
Grays River tule	0.76	0.85	1.00	1.00	0.76	0.85			1.76	2.64
Kalama River spring	0.76	0.85	1.00	1.00	0.76	0.85			1.87	2.80
Kalama River	0.89	0.99	1.00	1.00	0.89	0.99			1.06	1.58
Klaskanine River	0.80	0.89	1.00	1.00	0.80	0.89	2.30	3.27	1.54	2.30
Lewis River bright	0.97	0.99	1.00	1.00	0.97	0.99			1.05	1.11
Lewis River spring	0.81	0.91	1.00	1.00	0.81	0.91			1.46	2.20
Lewis R., E. Fork tule	0.99	0.99	1.00	1.00	0.99	0.99			1.03	1.03
Lewis & Clark River	0.49	0.54	1.00	1.00	0.49	0.54			10.34	15.93
Mill Creek fall	0.72	0.81	1.00	1.00	0.72	0.81	2.44	3.58	2.19	3.29
Plympton Creek	0.86	0.95	1.00	1.00	0.86	0.95	1.18	1.74	1.21	1.82
Sandy River late	0.98	0.98	1.00	1.00	0.98	0.98	1.00	1.00	1.07	1.09
Skamokawa Creek	0.74	0.82	1.00	1.00	0.74	0.82			2.05	3.08
Youngs River	0.84	0.94	1.00	1.00	0.84	0.94	6.73	8.32	1.25	1.88

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

6.3.5.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the proposed action would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, LCR chinook salmon. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately, and that the background survival rate will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. However, if current supplementation programs reduce the short-term extinction risk for wild fish, that effect is not reflected in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climatic conditions and other background factors influencing survival have been below average for most of the period included in this analysis. Assuming that these factors will continue as they have, on average, during the years influencing 1980-through-1998 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. NMFS does not rely on the expectation of improving ocean and other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.5.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the proposed action on survival below Bonneville Dam or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-5 are likely to be achieved through recent or anticipated future actions that affect other life stages.

Current FCRPS operations affect mainstem spawning and rearing habitat for the spawning aggregation of LCR chinook salmon observed in the Ives Island area during October 1999. Flow regulation may affect critical habitat for rearing in the estuary and plume. Available evidence is inferential, however, and thus insufficient for concluding that the proposed action will appreciably diminish the capacity of estuary or plume habitat to meet the biological requirements of listed fish. Because LCR chinook salmon were observed spawning in the Ives Island area only once, it is unlikely that the FCRPS is currently limiting the survival of this ESU below

Bonneville Dam or that the proposed action will change the survival rate of any of the subbasin populations considered in the quantitative analysis.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal and non-Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival and estuary survival. The proposed action, along with the future recovery efforts in the habitat and hatchery sectors anticipated in the Basinwide Recovery Strategy, is expected to be sufficient to meet survival and recovery indicator criteria.

6.3.6 Snake River Steelhead

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of SR steelhead in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Hydrosystem projects create substantial habitat blockages for this ESU. The major ones are the Hells Canyon Complex on the mainstem Snake River and Dworshak Dam on the North Fork of the Clearwater River. Minor blockages are common throughout the region. Steelhead spawning areas have been degraded by overgrazing, as well as by historical gold dredging and sedimentation due to poor land management. Hatchery fish are widespread and stray to spawn naturally throughout the region. In the 1990s, an average of 86% of adult steelhead passing Lower Granite Dam were of hatchery origin. Hatchery contribution to naturally spawning populations varies across the region, however, some stocks are dominated by hatchery fish, whereas others are composed of all wild fish.

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

6.3.6.1 Populations Evaluated

NMFS evaluated A-run and B-run aggregate groups of SR steelhead (McClure et al. 2000b,c). These analyses are based on Lower Granite Dam counts, with the two groups distinguished by date and/or size. Once past Lower Granite Dam, SR steelhead spawn in tributaries throughout the lower Snake River basin, and it is likely that there are multiple populations within these aggregates. However, populations have not yet been defined according to criteria in McElhany et al. (2000) and spawner data from tributaries are not available. The Idaho Department of Fish and Game, in comments on the July 27 draft biological opinion, suggested that NMFS should assign lower abundance levels to each aggregate group, to simulate the greater risk of extinction faced by smaller populations that probably exist in the basin. In response, NMFS evaluated the sensitivity of necessary survival changes to steelhead pseudopopulations, defined as 10% of the abundance of the A-run aggregate and 33% of the B-run aggregate abundance (McClure et al. 2000b; Appendix A). These approximations were based on information on spawning distribution contained in Busby et al. (1996) and the 1990 NWPPC subbasin plans (Tucannon River, Salmon River, Grande Ronde River, and Clearwater River plans). Those documents identify the major summer steelhead spawning areas with respect to each ESU. B-run steelhead are believed to return mainly to three general areas (Middle Fork Salmon River, Upper Salmon River, and the South Fork Salmon River). Summer steelhead returns classified as A-run appear to be distributed among a wider array of spawning areas throughout the Snake River region.

6.3.6.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from base period lambda necessary to achieve $\geq$50% likelihood of meeting the lambda $\geq$1.0 (Appendix A) recovery indicator criterion. Details of these estimates are included in Appendix A.

6.3.6.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from the base period will continue indefinitely. However, the juvenile SR steelhead survival rate associated with the proposed action represents an improvement from the average survival rate influencing base period adult returns. That is because many structural and operational modifications to the hydrosystem have been implemented since 1980, as described in Section 6.3.1.3.

Section 6.2.8 contains juvenile survival estimates for the proposed action, but no estimates of average juvenile survival during the base period are available. Neither PATH nor NMFS has attempted to estimate the SR steelhead survival rates, including transported fish and possible indirect effects. Because direct estimates of historical steelhead juvenile passage survival are not available, NMFS assumes that the proportional change in juvenile SR steelhead survival from the base to current (proposed action) condition equals the proportional change estimated for SR spring/summer chinook salmon in Section 6.3.1.3 (24% to 32%, depending on method). Improvements to the system over that period (e.g., new bypasses, increased spill levels, increased flow rates, and new transportation facilities) probably have affected spring-migrating yearling steelhead and yearling chinook similarly. The 1998 FCRPS Biological Opinion contains details regarding similar effects of the hydrosystem on the two ESUs. The 1998 FCRPS Biological Opinion relied on a comparison of SR spring/summer chinook and SR steelhead to draw conclusions for steelhead. Additional information about effects of the hydrosystem on each ESU is available in NMFS (2000e,h,i).

In addition to the change in juvenile passage survival, harvest rates changed significantly during this period. The average 1984-through-1997 harvest rates for A-run and B-run steelhead were obtained from ODFW and WDFW (2000). Estimates for 1980-through-1983 returns were not available, except for the run at large. NMFS compared this historical average with the Basinwide Recovery Strategy's 17% B-run harvest cap, which represents the most likely current and future B-run harvest rate. The Basinwide Recovery Strategy does not describe a similar harvest rate for A-run steelhead, so an approximation was obtained by multiplying the B-run harvest cap by the recent ratio of A:B harvest rates (Appendix A). The result was a 10% A-run current and future harvest rate. The reduced harvest rate represents a 7.2% A-run survival increase from the average survival during the 1980-to-1997 period and a 16.3% B-run survival increase.

The reduced harvest rates and the two alternative methods for estimating juvenile survival change result in estimates of total survival change ranging from 33% to 42% (1.33 to 1.42 times the average historical survival rate) for A-run steelhead and 44% to 54% (1.44 to 1.54 times the average historical survival rate) for B-run steelhead.

No other quantifiable survival rates changed significantly between the average base period condition and the current condition. For example, there is no evidence to suggest that adult survival through the hydrosystem has changed significantly under current operations, compared with average adult survival between 1980 and 1999. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above Lower Granite Dam that may have resulted from habitat and hatchery management actions, so no change in those survival rates was included in this quantitative analysis. In Section 6.3.6.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.6.4 Additional Necessary Survival Changes

Table 6.3-6 shows the effect of the 33% to 42% A-run survival rate increase and the 44% to 54% B-run survival increase expected from the proposed action on the future median annual population growth rates. The survival improvement is not sufficient to reduce the declining population trend for SR steelhead. Additional survival improvement greater than 56% to 370%, depending on assumptions and aggregate run, would be necessary to achieve the recovery indicator criterion of lambda greater than 1.0.

The effect of the proposed action on the ability to meet the recovery indicator criterion was not affected by the pseudopopulation sensitivity analysis because the pseudopopulations were assumed to have the same abundance trends as the A-run and B-run aggregates. The use of pseudopopulations did increase the risk of extinction, compared with that of the aggregates, but not significantly. For example, the highest estimate of the survival improvement necessary to meet the survival indicator criteria was 173% for the B-run aggregate and 188% for the B-run pseudopopulation (Table 6.3-6). In all cases, it was more difficult to meet the recovery indicator criteria than the survival indicator criteria, so the overall needed survival change was not affected by the use of pseudopopulations.

Table 6.3-6. Snake River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU aggregate	0.72	0.83	1.38	1.48	0.77	0.90	1.01	2.11	1.72	3.91
A-run aggregate	0.74	0.85	1.33	1.42	0.78	0.92	0.92	1.89	1.56	3.41
A-run pseudo-population[9]	0.74	0.85	1.33	1.42	0.78	0.92	1.04	2.10	1.56	3.41
B-run aggregate	0.74	0.84	1.44	1.54	0.79	0.89	1.28	2.73	2.09	4.70
B-run pseudo-population[10]	0.74	0.84	1.44	1.54	0.79	0.89	1.35	2.88	2.09	4.70

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents SR spring/summer chinook low estimate.
[4] High represents SR spring/summer chinook high estimate.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.
[9] Pseudopopulation is 10% of A-run aggregate abundance.
[10] Pseudopopulation is 33% of B-run aggregate abundance.

6.3.6.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Substantial comments primarily questioned the estimates of hydrosystem survival associated with the proposed action (addressed in Section 6.2); the method of estimating the expected proportional change in the juvenile survival rate from the average associated with base period returns (addressed with one new and one modified method of estimating the expected change for SR spring/summer chinook; the application of that survival change to steelhead was not questioned); the analytical assumption that all survival changes are achieved instantaneously; and the assumption that the effectiveness of hatchery-origin spawners may have been as low as 20% that of wild-origin spawners.

Concerns about the implementation schedule were primarily directed at the RPA in the July 27 draft biological opinion, which included actions not yet implemented. However, the analysis of the proposed action, as described above, is based on actions that are currently being implemented.

As described in Section 6.3.1.5 for SR spring/summer chinook, NMFS agrees that the full 20%-to-80% range of assumptions regarding the historical effectiveness of hatchery-origin natural spawners should be included in the analysis and in NMFS' conclusions. No comments were received to suggest that any range other than 20% to 80% should be applied to SR steelhead.

This analysis also contains assumptions that may make the results overly pessimistic. The main ones that may apply to SR steelhead are that all supplementation programs cease immediately, and that background survival will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. This assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. To the extent that current supplementation programs reduce the short-term extinction risk for wild fish, however, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climatic conditions and other background factors influencing survival have been below average for most of the period included in this analysis. The assumption that climatic conditions and other background factors influencing survival will continue as they have, on average, during the years influencing 1980 through 1997 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. NMFS does not rely on the expectation of improving ocean and other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.6.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-6 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above the uppermost dam). The sufficiency of Federal survival and recovery measures to augment survival improvements resulting from the FCRPS proposed action is highly uncertain unless there can also be reliable progress on non-Federal survival and recovery measures in other life stages. The proposed action includes language that may be interpreted as a commitment by the Action Agencies to undertake or fund some of these non-Federal measures. The biological assessment is not explicit enough, however, to reach that conclusion with certainty. NMFS concludes that some proportion of the additional survival improvements identified in Table 6.3-6 may be achieved through ongoing Federal activities and through the proposed action. However, it is unlikely that the necessary improvements can be fully achieved because of the limited commitment to fund non-Federal habitat and hatchery improvements to offset hydrosystem impacts in the Action Agencies' biological assessment.

6.3.7 Upper Columbia River Steelhead

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of UCR spring chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. Specifically, Chief Joseph and Grand Coulee dams block substantial portions of the historical spawning range. Habitat problems are largely related to irrigation diversions and hydroelectric dams, as well as degraded riparian and instream habitat from urbanization and livestock grazing. Hatchery fish are widespread and escape to spawn naturally throughout the region. The relative contribution of these hatchery spawners to natural production rates is unknown.

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

6.3.7.1 Populations Evaluated

Ford et al. (1999) identified at least three populations comprising this ESU: the Wenatchee River population, the Methow River population, and the Entiat River population. Ford et al. (1999) identified interim recovery goals for each population and included the criterion that all three must meet these goals for delisting. Steelhead spawner estimates are available only from dam counts, so Cooney (2000) evaluated the Methow River population based on Wells Dam counts and evaluated the combined Wenatchee River and Entiat River populations based on differences between Rock Island and Wells Dam counts. McClure et al. (2000b,c) analyzed the aggregate ESU based on Rock Island Dam counts.

6.3.7.2 Necessary Survival Change

McClure et al. (2000b,c) and Cooney (2000) described changes from the base period (1980 to 1996 for CRI aggregates; 1980 to 1999 for QAR populations) median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. Cooney (2000) also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the Methow and combined Wenatchee/Entiat population interim recovery abundance levels (Ford et al. 1999) in 48 and 100 years. NMFS (Appendix A) estimated the survival change necessary to meet the alternative recovery indicator criterion of lambda ≥ 1.0 for the aggregate run, using lambda estimates from McClure et al. (2000b) and methods described in Appendix A. The CRI analytical approach (McClure et al. 2000c) and the QAR analytical approach (Cooney 2000) produce different estimates of necessary survival changes for these populations. NMFS considers both approaches to have advantages and disadvantages and uses results from both to define a range of necessary survival change.

6.3.7.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from the base period will continue indefinitely. The Basinwide Recovery Strategy, however, identifies implementation of the Mid-Columbia HCP at five PUD projects as a probable element of recovery planning that is, therefore, included in the analysis, consistent with step 4 of the jeopardy analysis framework described in Section 1.3. The Basinwide Recovery Strategy estimates that this action will be implemented within 2 to 5 years. Cooney (2000, Table 20) estimates that implementation of the HCP will improve survival by 23% for the Wenatchee population, 33% for the Entiat population, and 38% for the Methow population.

NMFS estimates that juvenile survival from McNary Dam to Bonneville Dam has changed from the average survival rate affecting adult returns in 1980 through 1998 because transportation from McNary Dam has discontinued, and because structural and operational modifications to the four lower Columbia River dams have been implemented since 1980 (Section 6.3.1.3). The project modifications have improved survival for inriver migrants, but the system survival from McNary Dam to Bonneville has declined from the average rate during the base period, when a significant proportion of the smolts were transported (Cooney 2000; Appendix A). The proposed action specifies that nearly all fish shall remain in the river because of very low returns of transported smolts in 1994, after the new McNary bypass system was constructed (Appendix B to 1998 FCRPS Biological Opinion).

The size of the estimated decline in McNary-Bonneville juvenile survival depends on the estimate of historical differential post-Bonneville survival (D; see Section 6.2.3.3) during the years when smolts were transported from McNary Dam. NMFS evaluated D estimates ranging from 0.8 to 1.0, based on results of historical McNary transportation studies (Cooney 2000; reviewed in NMFS 2000i). Only a fraction of the run is transported for the proposed action, so estimating D under the proposed action is not necessary for this ESU. Cooney (2000, Table 23) estimated 1980-to-1994 juvenile survival from McNary to Bonneville at 60.7% and 69.0% for historical D estimates of 0.8 and 1.0, respectively. These historical survival estimates are higher than the SIMPAS McNary-to-Bonneville survival estimates from 1994 to 1999, which averaged 58.8%. The resulting change in lower river survival associated with the proposed action was -3% (D = 0.8) to -15% (D = 1.0).

Harvest rates have also declined over this period. The change in harvest rate estimated for SR A-run steelhead also applies to this ESU. This reduced harvest rate results in a 7.2% survival improvement.

Combining changes in survival resulting from implementation of the Mid-Columbia HCP, reduced harvest rates, and modifications to the four lower Columbia River FCRPS projects results in a 12% to 43% increase in survival, depending on the population under consideration and the historical D estimate (Table 6.3-3; Appendix A).

No other quantifiable survival rates changed significantly between that affecting base period adult returns and the current and expected future condition. For example, there is no evidence to suggest that adult passage survival through the hydrosystem has changed significantly under current operations, compared with average adult survival between 1980 and 1996/1998. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival (other than those expected from the HCP), estuary survival, and adult survival above the upper dam that may have resulted from habitat and hatchery management actions, so no change in those survival rates is included in this quantitative analysis. In Section 6.3.7.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.7.4 Additional Necessary Survival Changes

Table 6.3-7 shows the effect of the 12%-to-43% survival rate increase expected from the proposed action on the future median annual population growth rates for the Methow and Wenatchee/Entiat populations and the aggregate ESU. Because different methods were used to estimate the population requirements and the aggregate ESU requirements, differences may be a result of either the analytical method or the scale of the analysis. Low estimates of the expected population growth indicate that it will continue to be negative after HCP implementation and continuation of the proposed action. Higher estimates indicate that it will be stable or increasing, based on QAR population-specific results, or will continue to decrease, based on the CRI aggregate estimate. Additional survival improvements ranging from 8% to 243% (1.08 to 3.43

times the average base period survival rate) will be necessary to meet the recovery indicator criteria. The QAR population-level approach provides slightly more optimistic results than the CRI aggregate ESU approach, suggesting that a maximum 146% increase in survival is necessary.

Table 6.3-7. Upper Columbia River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

							Additional Change In Survival Needed to Achieve:			
Spawning Aggregation	**1980-Current Lambda**		**Expected Survival Change**		**Expected Lambda**		**5% Extinction Risk In 100 Years**		**50% Recovery In 48 Years or Lambda = 1.0**	
	Low[1]	**High[2]**	**Low[3]**	**High[4]**	**Low[5]**	**High[6]**	**Low[7]**	**High[8]**	**Low[7]**	**High[8]**
UCR steelhead aggregate - CRI	0.69	0.83	1.19	1.36	0.72	0.90	1.19	2.76	1.47	3.43
Methow - QAR	0.81	0.97	1.26	1.43	0.86	1.06	0.80	1.71	1.08	2.46
Wenatchee/Entiat - QAR[9]	0.85	0.94	1.12	1.28	0.87	1.00	0.88	1.49	1.17	1.96

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low represents an estimate of juvenile survival improvement based on assumption of historical D=0.8 from McNary Dam.
[4] High represents an estimate of juvenile survival improvement based on assumption of historical D=1.0 from McNary Dam.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.
[9] Expected survival change is based on the Wenatchee estimate of HCP survival increase (Cooney 2000, Table 20). Entiat estimate from same source is higher.

6.3.7.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to, or in some cases relevant to, UCR steelhead. However, three comments of particular relevance were that NMFS should not assume that the Mid-Columbia HCP will be implemented and achieve its survival goals within the time described in the Basinwide Recovery Strategy; that the analysis is overly optimistic because it assumes that all survival changes are achieved instantaneously; and that the analysis is overly optimistic because NMFS rejected the assumption of 80% effectiveness of hatchery-origin natural spawners.

The first two comments apply to implementation of the HCP because it is the only future survival improvement anticipated in the analysis. The implementation schedule for the HCP is discussed in Section 6.3.3.5. Regardless of the exact implementation schedule, the analysis described above does assume that HCP survival improvements are achieved immediately. NMFS conducted a sensitivity analysis on the effect of a 10-year delay in implementing *any* survival improvements over the base period (1980-to-1996/1998) average survival rate for UCR spring chinook (Section 6.3.3.5; Appendix C). Under this worst-case scenario, the CRI estimate of necessary survival change for the Wenatchee population increased significantly from the estimate that assumed immediate implementation. This extreme scenario is unlikely, since some improvements associated with the HCP have already been achieved, but NMFS considers the implications of delayed implementation qualitatively in reaching jeopardy conclusions for this ESU.

As described in Section 6.3.1.5 for SR spring/summer chinook, NMFS agrees that the full 20%-to-80% range of assumptions regarding the historical effectiveness of hatchery-origin natural spawners should be included in the analysis and in NMFS' conclusions. The results described above reflect that range. No comments were received to suggest that any range other than 20% to 80% should be applied to UCR steelhead.

This analysis contains assumptions that may make the results overly pessimistic. Two such assumptions are that all supplementation programs cease immediately, and that background survival will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. To the extent that current supplementation programs reduce the short-term extinction risk for wild fish, however, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climatic conditions and other background factors influencing survival have been below average for most of the period included in this analysis. The assumption that climatic conditions and other background factors influencing survival will continue as they have, on average, during the years influencing base period adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. The sensitivity of the results to projected 2000-to-2001 returns for UCR spring chinook indicates that necessary survival rates could decrease significantly if returns are as predicted (Section 6.3.3.5). NMFS does not rely on the expectation of improving ocean conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.7.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management, other than effects anticipated in the HCP. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-7 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above the uppermost dam). The sufficiency of Federal survival and recovery measures to augment survival improvements resulting from the FCRPS proposed action is highly uncertain unless there can also be reliable progress on non-Federal survival and recovery measures in other life stages. The proposed action includes language that may be interpreted as a commitment by the Action Agencies to undertake or fund some of these non-Federal measures. The biological assessment is not explicit enough, however, to reach that conclusion with certainty. NMFS concludes that some proportion of the additional survival improvements identified in Table 6.3-7 may be achieved through ongoing Federal activities and through the proposed action. However, it is unlikely that the necessary improvements can be fully achieved because of the limited commitment to fund non-Federal habitat and hatchery improvements to offset hydrosystem impacts in the Action Agencies' biological assessment.

6.3.8 Middle Columbia River Steelhead

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. They include timber harvest (altered riparian vegetation, unstable streambanks, and decreased habitat complexity), agricultural practices (channelization and loss of riparian vegetation), road construction, and urban and industrial development. Pelton Dam on the Deschutes River blocks access to historical spawning areas, and there are numerous minor blockages from smaller dams and impassable culverts throughout the region. In addition, the genetic integrity of the ESU is threatened by past and present hatchery practices. Hatchery fish are widespread and escaping to spawn naturally throughout the region, so that adults of hatchery origin make up a substantial portion of the spawning population in several basins (e.g., the Umatilla and Deschutes rivers).

In this section, NMFS evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions are sufficient to change annual population growth rates such that survival and recovery are likely.

6.3.8.1 Populations Evaluated

NMFS evaluated four spawning aggregations of MCR steelhead. The Yakima River aggregation passes through four FCRPS projects, the Umatilla River aggregation passes through three FCRPS projects, and the Deschutes River and Warm Springs aggregations pass through two FCRPS projects. NMFS has not yet determined which, if any, of these spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the four aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

6.3.8.2 Necessary Survival Change

McClure et al. (2000b) described changes from the 1980-to-1994 (Yakima and Warm Springs) or 1980-to-1996 (Deschutes and Umatilla) median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria. NMFS also estimated the change from base period (1980 to 1994/1996) lambda necessary to meet the recovery indicator criterion of lambda $\geq$1.0 (Appendix A). Details of these estimates are found in Appendix A.

6.3.8.3 Expected Survival Change

The necessary improvements in population growth rate described above are based on the assumption that life-stage survival rates influencing adult returns from the base period will continue indefinitely. The juvenile SR spring/summer chinook salmon survival rate through the lower Columbia River associated with the proposed action, however, represents a change from the average survival rate influencing base period adult returns. That is because many structural and operational modifications to the Federal hydrosystem have been implemented since 1980 (Section 6.3.1.3) and, for the Yakima spawning aggregation, transportation from McNary Dam has been curtailed since 1994.

The Yakima spawning aggregation passes through the same four FCRPS projects as the UCR steelhead ESU and is, therefore, likely to experience the same survival change estimated for that ESU. The FCRPS project modifications have improved survival for inriver migrants, but the system survival from McNary Dam to Bonneville has declined from the average rate during the base period, when a significant proportion of the smolts were transported (Cooney 2000; Appendix A). The proposed action specifies that nearly all fish will remain in the river because of very low returns of transported smolts in 1994, after the new McNary bypass system was constructed (Appendix B to 1998 FCRPS Biological Opinion). The size of the estimated decline in McNary-Bonneville juvenile survival for the Yakima aggregation depends on the estimate of historical differential post-Bonneville survival (D; see Section 6.2.3.3) during the years when smolts were transported from McNary Dam. NMFS evaluated D estimates ranging from 0.8 to 1.0, based on results of historical McNary transportation studies (Cooney 2000; reviewed in NMFS 2000i). Only a fraction of the run is transported for the proposed action, so estimating D under the proposed action is not necessary for this ESU. Cooney (2000, Table 23) estimated 1980-to-1994 juvenile survival from McNary to Bonneville at 60.7% and 69.0% for historical D estimates of 0.8 and 1.0, respectively. These historical survival estimates are higher than the SIMPAS McNary-to-Bonneville survival estimates from 1994 to 1999, which averaged 58.8%. The resulting change in lower river survival associated with the proposed action was -3% (D = 0.8) to -15% (D = 1.0) for the Yakima River spawning aggregation.

The Umatilla River spawning aggregation passes through three FCRPS projects below the last transportation site. NMFS compared the estimate in Cooney (2000, Table 22) of average 1980-to-1994 inriver survival through these projects (61.3%) with the average SIMPAS 1994-to-1999 estimate through the same projects (65.1%). The resulting survival change for the Umatilla spawning aggregate is 6%.

The Deschutes River and Warm Springs spawning aggregations pass through two FCRPS projects below the last transportation site. NMFS compared the estimate in Cooney (2000, Table 22) of average 1980-to-1994 inriver survival through these projects (75.7%) with the average SIMPAS 1994-to-1999 estimate through the same projects (75.7%). No change in juvenile survival, therefore, is anticipated for the Deschutes and Warm Springs spawning aggregations.

In addition to changes in juvenile passage survival, adult harvest rates have changed from the average during the period. NMFS assumes that these spawning aggregations have experienced a change similar to that estimated for other summer-run steelhead in the Columbia basin. The A-run harvest rate reduction resulted in a survival increase of 7.2% for SR steelhead (Section 6.3.6.3). NMFS estimates that the same survival change affects all four MCR steelhead spawning aggregations in this analysis.

Combining changes in survival resulting from modifications to the four lower Columbia River FCRPS projects and reductions in harvest rates results in a -9% to +4% change in survival for the Yakima spawning aggregation, a 14% increase for the Umatilla spawning aggregation, and a 7% increase for the Deschutes and Warm Springs spawning aggregations (Table 6.3-8; Appendix A).

No other quantifiable survival rates changed significantly between the average base period condition and the current condition. For example, there is no evidence to suggest that adult survival through the hydrosystem has changed significantly under current operations, compared with average adult survival between 1980 and 1994/1996. NMFS was unable to quantitatively estimate possible changes in egg-to-smolt survival, estuary survival, and adult survival above the upper dam that may have resulted from habitat and hatchery management actions, so no change in those survival rates was included in this quantitative analysis. In Section 6.3.8.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.8.4 Additional Necessary Survival Changes

Table 6.3-8 shows the effect of the -9% to +14% survival rate change expected from the proposed action on the future median annual population growth rates for the four MCR steelhead spawning aggregations in this analysis. Population growth rates are expected to be negative for all aggregations, except for an upward trend under the highest estimate of lambda for the Yakima River aggregation. Additional survival changes of 53% to 270% (1.53 to 3.70 times the base period average survival rates) are necessary to meet recovery indicator criteria for the Deschutes, Warm Springs, and Umatilla spawning aggregations. A 0%-to-10% improvement (0.96 to 1.10 times the average base period survival rate) is needed for the Yakima River aggregation to meet the survival indicator criterion, which is the more difficult criterion to meet for this aggregation.

Table 6.3-8. Mid-Columbia River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU aggregate	0.77	0.84	1.05	1.08	0.78	0.86	N/A	N/A	2.22	3.68
Deschutes R. summer	0.77	0.84	1.07	1.07	0.78	0.85	1.45	2.34	2.30	3.70
Warm Springs hatchery summer	0.91	0.91	1.07	1.07	0.92	0.92	1.32	1.35	1.54	1.54
Umatilla R. summer	0.90	0.90	1.14	1.14	0.93	0.92	1.02	1.00	1.53	1.48
Yakima R. summer	1.01	1.04	0.91	1.04	1.00	1.04	0.96	1.10	0.80	1.01

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] Low for Yakima R. represents an estimate of juvenile survival improvement based on assumption of historical D=0.8 from McNary Dam.
[4] High for Yakima R. represents an estimate of juvenile survival improvement based on assumption of historical D=1.0 from McNary Dam.
[5] Low represents the low 1980-to-1999 lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-1999 lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

6.3.8.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the proposed action's ability to achieve survival and recovery indicator criteria. Most comments were not specific to, or in some cases relevant to, MCR steelhead. However, two comments of particular relevance were that the analysis is overly optimistic because it assumes that all survival changes are achieved instantaneously, and that the analysis is overly optimistic because NMFS rejected the assumption of 80% effectiveness of hatchery-origin natural spawners.

Concerns about the implementation schedule were primarily directed at the RPA in the July 27 draft biological opinion, which included actions not yet implemented. However, the analysis of the proposed action, as described above, is based on actions that are currently being implemented.

As described in Section 6.3.1.5 for SR spring/summer chinook, NMFS agrees that the full 20%-to-80% range of assumptions regarding historical effectiveness of hatchery-origin natural spawners should be included in the analysis and in NMFS' conclusions. The results described above reflect that range. No comments were received to suggest that any range other than 20%-to-80% should be applied to MCR steelhead.

This analysis contains assumptions that may make the results overly pessimistic. Two such assumptions are that all supplementation programs cease immediately, and that background survival will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. This assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. However, to the extent that current supplementation programs reduce the short-term extinction risk for wild fish, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climatic conditions and other background factors influencing survival have been below average for most of the time period included in this analysis. The assumption that climatic conditions and other background factors influencing survival will continue as they have, on average, during the years influencing base period adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. The sensitivity of the results to projected 2000-to-2001 returns for UCR spring chinook indicated that necessary survival rates could decrease significantly if returns are as predicted (Section 6.3.3.5). NMFS does not rely on the expectation of improving ocean conditions, but this factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.8.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-8 are likely to be achieved through recent or anticipated future actions that affect other life stages.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional needed survival improvement may result from ongoing Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above the uppermost dam). The sufficiency of Federal survival and recovery measures to augment survival improvements resulting from the FCRPS proposed action is highly uncertain unless there can also be reliable progress on non-Federal survival and recovery measures in other life stages. The proposed action includes language that may be interpreted as a commitment by the Action Agencies to undertake or fund some of these non-Federal measures. The biological assessment is not explicit enough, however, to reach that conclusion with certainty. NMFS concludes that some proportion of the additional survival improvements identified in Table 6.3-8 may be achieved through ongoing Federal activities and through the proposed action. However, it is unlikely that the necessary improvements can be fully achieved because of the limited commitment to fund non-Federal habitat and hatchery improvements to offset hydrosystem impacts in the Action Agencies' biological assessment.

6.3.9 Upper Willamette River Steelhead

Evaluation of the species-level effects of the proposed action requires placing the action-area effects of the proposed action in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of UWR steelhead in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. They include the loss of habitat due to inundation or blockages resulting from the construction of numerous tributary hydroelectric and irrigation facilities; and habitat degradation due to timber harvest, development (agricultural, municipal, and industrial), dam development, and river channelization and dredging. Many of these activities result in poor water quality, high sediment loads, altered thermal regimes, and a large reduction in available spawning and rearing habitat. Overharvest and hatchery production have also contributed to the decline of this ESU.

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions could increase annual population growth rates such that survival and recovery are likely.

6.3.9.1 Populations Evaluated

NMFS quantitatively evaluated four spawning aggregations: the Molalla, North Santiam, South Santiam, and Calapooia river populations. NMFS has not yet determined which, if any, of the UWR steelhead spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the four aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

6.3.9.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the four spawning aggregations. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the recovery indicator criterion of lambda ≥1.0 for each aggregation. Details of these estimates are provided in Appendix A.

6.3.9.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for UWR steelhead, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. For this winter-run steelhead ESU, NMFS cannot identify any significant changes in survival rates under current or expected future conditions compared to those that influenced the base period adult returns. Survival changes due to implementing the proposed action can be quantified only for species that migrate past mainstem dams, which excludes UWR steelhead. NMFS was unable to quantify potential changes in egg-to-smolt survival, estuary survival, or adult survival that may have resulted from recent or ongoing habitat and hatchery management actions. In Section 6.3.9.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the proposed action.

6.3.9.4 Additional Necessary Survival Changes

Table 6.3-9 shows that the proposed action is not expected to increase the population survival rate; negative median annual population growth rates are expected to continue for each of the four UWR steelhead spawning aggregations. Survival improvements needed to meet the recovery indicator criteria range from 30% to 108% (1.30 to 2.08 times the average base period survival rates).

6.3.9.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the proposed action would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, UWR steelhead. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately and that the background survival rate will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for, and the effects of, the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. To the extent that current supplementation programs reduce the short-term extinction risk for wild fish, however, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Table 6.3-9. Upper Willamette River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

							Additional Change In Survival Needed to Achieve:			
Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU aggregate	0.88	0.92	1.00	1.00	0.88	0.92	1.13	1.39	1.37	1.69
Molalla River	0.84	0.91	1.00	1.00	0.84	0.91	1.34	1.96	1.45	2.08
N. Santiam River	0.89	0.92	1.00	1.00	0.89	0.92	1.20	1.34	1.42	1.58
S. Santiam River	0.87	0.94	1.00	1.00	0.87	0.94	1.06	1.50	1.30	1.78
Calapooia River	0.93	0.93	1.00	1.00	0.93	0.93	1.53	1.53	1.36	1.36

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climate and other background factors influencing survival have been below average for most of the period included in this analysis. Assuming that these factors will continue as they did, on average, during the years influencing 1980-through-1997 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. NMFS does not rely on the expectation of improving ocean and other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.9.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the proposed action on survival below Bonneville Dam, or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-9 are likely to be achieved through recent or anticipated future actions that affect other life stages.

Current FCRPS operations do not affect mainstem spawning or rearing habitat for UWR steelhead, although flow regulation may affect critical habitat for rearing in the estuary and plume. Available evidence is inferential, however, and thus insufficient for concluding that the proposed action will appreciably diminish the capacity of estuary or plume habitat to meet the biological requirements of listed fish. Thus, it is unlikely that the FCRPS is currently limiting the survival of this ESU below Bonneville Dam or that the proposed action will change the population survival rate.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional needed survival improvement may result from ongoing Federal and non-Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, estuary survival, and prespawning adult survival (above Willamette Falls). The proposed action, along with the future recovery efforts in the habitat and hatchery sectors anticipated in the Basinwide Recovery Strategy, is expected to be sufficient to meet survival and recovery indicator criteria.

6.3.10 Lower Columbia River Steelhead

Evaluation of the species-level effects of the proposed action requires placing the action-area effects of the proposed action in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of LCR steelhead in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include timber harvest (altered riparian vegetation, unstable streambanks, and decreased habitat complexity), agricultural practices (channelization and loss of riparian vegetation), road construction, and urban and industrial development. Upstream passage is blocked by dams on the Lewis, Clackamas, Sandy, and Hood rivers, and there are minor blockages (such as impassable culverts) throughout the region. Mudflows from the eruption of Mt. St. Helens (1980) significantly disrupted and degraded habitat in the South Fork Toutle and Green rivers, as did post-eruption dredging, diking, and bank protection works in the Cowlitz River below its confluence with the Toutle River. In addition, the genetic integrity of the ESU is threatened by past and present hatchery practices. Each year, hatcheries release approximately 3 million steelhead smolts in basins occupied by the ESU (Busby et al. 1996). In many basins, hatchery strays compose most of the spawning population.

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions could increase annual population growth rates such that survival and recovery are likely.

6.3.10.1 Populations Evaluated

NMFS quantitatively evaluated seven spawning aggregations below Bonneville Dam. Adequate information was not available for similar analyses for spawning aggregations above Bonneville Dam. NMFS has not yet determined which, if any, of the LCR steelhead spawning aggregations represent "populations," as defined by McElhany et al. (2000), but treating the seven aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

6.3.10.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rates (lambda) that are necessary to meet the survival indicator criteria for the seven subbasin spawning aggregations. NMFS also estimated the change from the base period lambda necessary to achieve $\geq$50% likelihood of meeting the recovery indicator criterion of lambda $\geq$1.0 for each aggregation. Details of these estimates are provided in Appendix A.

6.3.10.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for LCR steelhead, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns for winter steelhead in the Clackamas, Green, Kalama, Sandy, and Toutle rivers will continue indefinitely. Adult harvest rates for summer steelhead in the Clackamas and Kalama subbasins have changed, however. NMFS assumes that the size of the change from the average rate over the base period is similar to that estimated for other summer-run steelhead in the Columbia basin. The A-run harvest rate reduction resulted in a survival increase of 7.2% for SR steelhead (Section 6.3.6.3).

NMFS was unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 6.3.10.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA. Although structural and operational modifications have been made to Bonneville Dam since 1980, none of the spawning aggregations for which NMFS could perform quantitative analyses passes this project.

6.3.10.4 Additional Necessary Survival Changes

Table 6.3-10 shows that the proposed action is expected to increase the survival rate of two of the LCR steelhead spawning aggregations because of harvest rate reductions. Negative median

Table 6.3-10. Lower Columbia River steelhead estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

							Additional Change In Survival Needed to Achieve:			
Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		5% Extinction Risk In 100 Years		50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU aggregate	0.80	0.91	1.00	1.00	0.80	0.91	N/A	N/A	1.53	2.71
Aggregations Above Bonneville Dam										
(insufficient information for analysis)										
Aggregations Below Bonneville Dam										
Clackamas R. summer	0.73	0.83	1.07	1.07	0.74	0.84	1.75	3.34	2.44	4.76
Clackamas R. winter	0.76	0.88	1.00	1.00	0.76	0.88	1.35	2.57	1.75	3.43
Green R. winter	0.90	0.90	1.00	1.00	0.90	0.90	1.80	1.80	1.58	1.58
Kalama R. summer	0.77	0.91	1.07	1.07	0.78	0.92	1.09	2.50	1.51	3.67
Kalama R. winter	0.90	0.97	1.00	1.00	0.90	0.97	1.00	1.14	1.13	1.58
Sandy R. winter	0.85	0.91	1.00	1.00	0.85	0.91	1.19	1.63	1.49	2.08
Toutle R. winter	0.88	0.88	1.00	1.00	0.88	0.88	1.30	1.30	1.81	1.81

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

annual population growth rates are expected to continue for all seven aggregations, however. Survival improvements needed to meet the survival and recovery indicator criteria range from 13% to 376% (1.13 to 4.76 times the average base period survival rates).

6.3.10.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations commented that the analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the proposed action would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, LCR steelhead. In fact, this analysis contains assumptions that may make the results overly pessimistic. For example, NMFS assumes that all supplementation programs cease immediately, and that the background survival rate will continue as it has since 1980.

Section 6.3.1.5 describes the rationale for and the effects of the assumption that supplementation will cease immediately. That assumption is consistent with ESA precepts, which address the status of populations in the wild, and with concerns about the long-term negative impacts of hatchery programs. However, if current supplementation programs reduce the short-term extinction risk for wild fish, that effect is not included in the results of this analysis. NMFS will consider that factor qualitatively in reaching a jeopardy conclusion.

Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climate and other background factors influencing survival have been below average for most of the period included in this analysis. Assuming that these factors will continue as they have, on average, during the years influencing 1980-through-1998 adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. NMFS does not rely on the expectation of improving ocean and other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.10.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the proposed action on survival below Bonneville Dam or changes in survival in other life stages that result from habitat or hatchery management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-10 are likely to be achieved through recent or anticipated future actions that affect other life stages.

Current FCRPS operations do not affect mainstem spawning or rearing habitat for LCR steelhead, although flow regulation may affect critical habitat for rearing in the estuary and plume. Available evidence is inferential, however, and thus insufficient for concluding that the proposed action will appreciably diminish the capacity of estuary or plume habitat to meet the biological requirements of listed fish. Thus, it is unlikely that the FCRPS is currently limiting the survival of this ESU below Bonneville Dam or that the proposed action will change the population survival rate.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal and non-Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival and estuary survival. The proposed action, along with the future recovery efforts in the habitat and hatchery sectors anticipated in the Basinwide Recovery Strategy, is expected to be sufficient to meet interim survival and recovery criteria.

6.3.11 Columbia River Chum Salmon

Evaluation of the species-level effects of the proposed action requires placing the action-area effects of the proposed action in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of CR chum salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include water withdrawals, conveyance, storage, and flood control, resulting in insufficient flows, stranding, juvenile entrainment, and instream temperature increases; logging and agriculture (loss of large woody debris, sedimentation, loss of riparian vegetation, and habitat simplification); mining (especially gravel removal, dredging, and pollution); urbanization (stream channelization, increased runoff, pollution, and habitat simplification); development of many small hydropower facilities in lower river areas; passage mortality at Bonneville Dam; and substantial habitat loss in the Columbia River estuary and associated areas.

In this section, NMFS quantitatively evaluates the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle. NMFS determines whether the survival rates expected from the proposed action and other likely actions could increase annual population growth rates such that survival and recovery are likely.

6.3.11.1 Populations Evaluated

NMFS quantitatively evaluated six spawning aggregations below Bonneville Dam. NMFS has not yet determined which, if any, of the CR chum salmon spawning aggregations represent populations, as defined by McElhany et al. (2000), but treating the six aggregations as independent populations satisfies the statistical assumptions inherent in the analysis.

6.3.11.2 Necessary Survival Change

McClure et al. (2000b) described changes from the base period median annual population growth rate (lambda) that are necessary to meet the survival indicator criteria for the six spawning aggregations. NMFS also estimated the change from base period lambda necessary to achieve ≥50% likelihood of meeting the recovery indicator criterion of lambda ≥1.0 for each aggregation. Details of these estimates are provided in Appendix A.

6.3.11.3 Expected Survival Change

NMFS' calculation of the necessary survival change (improvement in population growth rate) for CR chum salmon, referenced above, assumes that the life-stage survival rates that influenced the base period adult returns will continue indefinitely. Although structural and operational modifications have been made to Bonneville Dam since 1980, none of the spawning aggregations for which NMFS could perform quantitative analyses passes this project. Further, NMFS was unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat and hatchery management actions. Instead, in Section 6.3.11.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from habitat and hatchery actions described in the Basinwide Recovery Strategy.

6.3.11.4 Additional Necessary Survival Changes

Table 6.3-11 shows that the proposed action is not expected to increase spawning aggregation survival rates. Negative median annual population growth rates are expected to continue for two of the CR chum salmon spawning aggregations (mainstem Grays River and Hamilton Creek). An additional survival improvement of from 18% to 36% (1.18 to 1.36 times the average base period survival rates) is needed to meet the recovery indicator criteria for these two spawning aggregations.

6.3.11.5 Other Factors Influencing Quantitative Analytical Results

Several agencies and organizations comments that NMFS' analysis in the July 27 draft biological opinion, which is very similar to this analysis, produced an overly optimistic estimate of the likelihood that the proposed action would meet the survival and recovery indicator criteria. However, these comments were not specific to, or relevant to, CR chum salmon. In fact, this analysis contains an assumption that may make the results overly pessimistic. Section 6.3.1.5 reviews common trends among Pacific Northwest salmonid stocks, which indicate that climate and other background factors influencing survival have been below average for most of the period included in this analysis. Assuming that these factors will continue as they have, on average, during the years influencing base period (1980-through-1998/1999) adult returns may be pessimistic if common survival rates return to average or above-average levels in the future. NMFS does not rely on the expectation of improving ocean or other climatic conditions, but that factor is considered qualitatively in reaching a jeopardy conclusion.

6.3.11.6 Qualitative Assessment of Egg-to-Smolt Survival, Estuarine Survival, and Prespawning Adult Survival Changes Caused by Human Activities

The quantitative analysis described above does not include qualitative assessments of the effects of the RPA on survival below Bonneville Dam or changes in survival in other life stages that result from habitat management. In this section, NMFS qualitatively evaluates the question whether the additional necessary survival improvements described in Table 6.3-11 are likely to be achieved through recent or anticipated future actions that affect other life stages. NMFS was also unable to quantify potential changes in egg-to-smolt or estuary survival that may have resulted from recent or ongoing habitat management actions. Instead, in Section 9.7.2.11.6, NMFS makes a qualitative judgment about whether further changes in survival can be expected from the habitat and hatchery actions described in the Basinwide Recovery Strategy and the RPA.

Table 6.3-11. Columbia River chum salmon estimates of current and expected median annual population growth rate (lambda), expected survival change from proposed action, and additional per-generation survival improvements needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action.

Spawning Aggregation	1980-Current Lambda		Expected Survival Change		Expected Lambda		Additional Change In Survival Needed to Achieve: 5% Extinction Risk In 100 Years		Additional Change In Survival Needed to Achieve: 50% Recovery In 48 Years or Lambda = 1.0	
	Low[1]	High[2]	Low[3]	High[4]	Low[5]	High[6]	Low[7]	High[8]	Low[7]	High[8]
ESU aggregate	1.04	1.04	1.00	1.00	1.04	1.04	N/A	N/A	0.88	0.88
Aggregations Above Bonneville Dam (insufficient information for analysis)										
Aggregations Below Bonneville Dam										
Grays R. west fork	1.23	1.23	1.00	1.00	1.23	1.23	N/A	N/A	0.47	0.47
Grays R. mouth to head	0.96	0.96	1.00	1.00	0.96	0.96	N/A	N/A	1.18	1.18
Hardy Creek	1.05	1.05	1.00	1.00	1.05	1.05	N/A	N/A	0.85	0.85
Crazy Johnson	1.16	1.16	1.00	1.00	1.16	1.16	N/A	N/A	0.59	0.59
Hamilton Creek	0.92	0.92	1.00	1.00	0.92	0.92	N/A	N/A	1.36	1.36
Hamilton Springs	1.11	1.11	1.00	1.00	1.11	1.11	N/A	N/A	0.68	0.68

[1] Low represents assumption that hatchery-origin natural spawners have been 80% as effective as wild spawners historically.
[2] High represents assumption that hatchery-origin natural spawners have been 20% as effective as wild spawners historically.
[3] No quantifiable change in survival is expected.
[4] No quantifiable change in survival is expected.
[5] Low represents the low 1980-to-current lambda estimate multiplied by the low survival improvement estimate, raised to the power of 1/mean generation time.
[6] High represents the high 1980-to-current lambda estimate multiplied by the high survival improvement estimate, raised to the power of 1/mean generation time.
[7] Low represents the lowest estimate of needed survival improvement (Appendix A) divided by the high estimate of the expected survival improvement.
[8] High represents the highest estimate of needed survival improvement (Appendix A) divided by the low estimate of the expected survival improvement.

Although some adult CR chum salmon are known to pass Bonneville Dam each year, spawning is essentially restricted to two areas below Bonneville: the Grays River basin in the Columbia River estuary, and the Hardy and Hamilton creek/Ives Island complex. According to BPA's 50-year simulation of base case operations, the proposed action would adversely affect use of much of the latter spawning habitat in a high proportion of water years. Load-following operations further reduce habitat quality by alternately watering and dewatering redds and stranding juveniles and adults. As described in Section 6.3.11, the productivity of CR chum salmon appears limited by the availability of spawning habitat. Although much of the historical range has been lost due to detrimental land use practices in lower river tributaries, the proposed action is likely to limit spawning habitat quantity and quality in a large part of the species' current range. Thus, FCRPS operations, coupled with survival in other life stages, affect the likelihood of meeting the survival and recovery indicator criteria.

After reviewing numerous biological opinions recently issued for hatchery and habitat actions and the general discussion of these actions in the Basinwide Recovery Strategy, NMFS concludes that some proportion of the additional necessary survival improvement may result from ongoing Federal and non-Federal conservation efforts to improve habitat and hatchery practices. The improvements will probably be expressed as changes from the average rates of base period, egg-to-smolt survival, and estuary survival. The proposed action, however, along with the future recovery efforts in the habitat and hatchery sectors anticipated in the Basinwide Recovery Strategy, is not expected to be sufficient to meet survival and recovery indicator criteria.

6.3.12 Snake River Sockeye Salmon

Evaluation of the species-level effects of the proposed action requires placing the action-area effects of the proposed action in the context of the full life cycle. The factors described in Section 6.2.9 affect elements of critical habitat and the survival and recovery of SR sockeye salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix C) limits this ESU over its full range. These include tributary hydropower and irrigation storage projects that block or restrict fish passage, water withdrawals that dewater streams, and unscreened diversions.

Because the abundance of SR sockeye salmon is extremely low, the risk of extinction cannot be calculated using the methods that NMFS employs in this biological opinion. The risk is undoubtedly very high, however, due to the extreme low abundance of SR sockeye salmon in recent years, this ESU has not been used in passage survival studies. NMFS has not, therefore, estimated total system survival under the proposed action for this ESU. Assuming that juvenile mortality in the action area is similar to that of other yearling migrants, the proposed action is likely to contribute to the ongoing high risk of extinction. The survival rate in the action area is not known with certainty, but survival resulting from the proposed action is clearly lower than that needed to meet the survival and recovery standards. Other factors also affect elements of critical habitat and thus contribute to this ESU's high risk of extinction (summarized in Section

4.1 and Appendix C), but the FCRPS is a significant factor. The high risk of extinction is partially mitigated by a captive breeding program, funded by the Action Agencies, which provides some assurance that SR sockeye salmon will not go extinct in the immediate future. However, long-term survival and recovery in the wild require a substantial increase in survival through the FCRPS and in other life stages. The proposed action, along with the future recovery efforts in the habitat and hatchery sectors anticipated in the Basinwide Recovery Strategy, is not expected to be sufficient to meet survival and recovery indicator criteria.

6.3.13 Summary—Effects of Proposed Action on Biological Requirements Over Full Life Cycle

The ESU-specific analyses in Sections 6.3.1 through 6.3.11 include both quantitative and qualitative assessments.[9] The quantitative analyses show that recent survival changes, if continued into the future, will increase the likelihood of meeting survival and recovery indicator criteria for stocks that pass through one or more FCRPS projects. Summer steelhead stocks throughout the basin, including two of the spawning aggregations in the LCR steelhead ESU, will also benefit from recent harvest reductions. For all ESUs, however, many stocks will need additional survival improvements beyond those expected from the proposed action and all other reasonably foreseeable recovery activities, ranging in size from a few percentage points to several orders of magnitude (Table 6.3-12).[10]

NMFS' qualitative assessment considers the extent to which the proposed action (and other reasonably foreseeable recovery activities) affects the capacity of critical habitat to provide biological requirements for listed fish. In addition to the likely effects of the proposed action, a large number of factors (e.g., tributary land use practices, interactions with hatchery fish, and ocean conditions) affect the current population trends of Columbia basin salmonids. These effects are organized by critical habitat type (juvenile rearing areas, juvenile migration corridors, areas for growth and development, adult migration corridors, and spawning habitat) in Table 6.3-13. As shown in that table, the FCRPS has the potential to diminish the value of critical habitat for survival and recovery across much of the life cycle for some species. SR fall chinook salmon, for example, spawn in the tailraces of several lower Snake River projects and rear in the FCRPS during their juvenile migration, as well as experiencing the effects of project passage.

In contrast, based on the best scientific information now available, the effects of current FCRPS operations appear to be relatively minor for UWR and LCR chinook salmon and for UWR and LCR steelhead; the Upper Willamette River ESUs do not pass any FCRPS projects, and only part of the spawning aggregations comprising each of the Lower Columbia River ESUs pass even one project. Current FCRPS operations do not affect mainstem spawning or rearing habitat for those species, although flow regulation may affect critical habitat for rearing in the estuary and plume.

[9] Quantitative analyses are not possible for SR sockeye salmon.

[10] Critical assumptions that influence results for each ESU are discussed in the preceding sections.

Evidence of effects in the estuary and plume is inferential, however, and insufficient for concluding that the proposed action will appreciably diminish the capacity of those areas to meet the biological requirements of listed fish. This issue requires further study.

Table 6.3-12. Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action. "Low" and "High" estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change			
Spawning Aggregation	Low	High		
Snake River Spring/Summer Chinook				
ESU aggregate	53	98		
Bear Valley/Elk creeks	0	0		
Imnaha River	32	74		
Johnson Creek	0	0		
Marsh Creek	2	17		
Minam River	0	33		
Poverty Flats	0	0		
Sulphur Creek	0	10		
Alturas Lake Creek	181	200	*	Based only on lambda ≥ 1.0
American River	16	24	*	Based only on lambda ≥ 1.0
Big Sheep Creek	35	65	*	Based only on lambda ≥ 1.0
Beaver Creek	0	0	*	Based only on lambda ≥ 1.0
Bushy Fork	0	0	*	Based only on lambda ≥ 1.0
Camas Creek	9	16	*	Based only on lambda ≥ 1.0
Cape Horn Creek	0	0	*	Based only on lambda ≥ 1.0
Catherine Creek	57	142	*	Based only on lambda ≥ 1.0
Catherine Creek North Fork	9	17	*	Based only on lambda ≥ 1.1
Catherine Creek South Fork	110	124	*	Based only on lambda ≥ 1.2
Crooked Fork Creek	0	0	*	Based only on lambda ≥ 1.0
Grande Ronde River	66	154	*	Based only on lambda ≥ 1.0
Knapp Creek	27	36	*	Based only on lambda ≥ 1.0
Lake Creek	0	0	*	Based only on lambda ≥ 1.0
Lemhi River	0	0	*	Based only on lambda ≥ 1.0
Lookingglass Creek	111	240	*	Based only on lambda ≥ 1.1
Loon Creek	0	0	*	Based only on lambda ≥ 1.0
Lostine Creek	20	50	*	Based only on lambda ≥ 1.0
Lower Salmon River	11	19	*	Based only on lambda ≥ 1.0
Lower Valley Creek	8	15	*	Based only on lambda ≥ 1.0
Moose Creek	0	4	*	Based only on lambda ≥ 1.0
Newsome Creek	0	0	*	Based only on lambda ≥ 1.0

Table 6.3-12 (continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action. "Low" and "High" estimates are based on a range of assumptions, as described in the text. A value of, for example, "8" indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change		
Spawning Aggregation	**Low**	**High**	
Red River	16	23	* Based only on lambda ≥ 1.0
Salmon River East Fork	0	7	* Based only on lambda ≥ 1.0
Salmon River South Fork	0	0	* Based only on lambda ≥ 1.0
Secesh River	0	0	* Based only on lambda ≥ 1.0
Selway River	13	21	* Based only on lambda ≥ 1.0
Sheep Creek	106	120	* Based only on lambda ≥ 1.0
Upper Big Creek	0	0	* Based only on lambda ≥ 1.0
Upper Salmon River	18	26	* Based only on lambda ≥ 1.0
Upper Valley Creek	0	0	* Based only on lambda ≥ 1.0
Wallowa Creek	48	58	* Based only on lambda ≥ 1.0
Wenaha River	19	74	* Based only on lambda ≥ 1.0
Whitecap Creek	19	27	* Based only on lambda ≥ 1.0
Yankee Fork of Salmon River	32	41	* Based only on lambda ≥ 1.0
West Fork of Yankee Fork, Salmon River	0	0	* Based only on lambda ≥ 1.0
Snake River Fall Chinook			
Aggregate	6	64	
Upper Columbia River Spring Chinook			
ESU aggregate - CRI	55	86	
Methow River-QAR	45	65	
Entiat River-QAR	60	82	
Wenatchee River-QAR	77	153	
Methow River-CRI	55	123	
Entiat River-CRI	54	156	
Wenatchee River-CRI	116	226	
Upper Willamette River Chinook			
McKenzie River above Leaburg Dam	9	65	

Table 6.3-12 (continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action. "Low" and "High" estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change			
Spawning Aggregation	Low	High		
Lower Columbia River Chinook				
Aggregations Above Bonneville Dam				
(insufficient information for analysis)				
Aggregations Below Bonneville Dam				
Bear Creek	114	213		
Big Creek	31	97		
Clatskanie River	193	312		
Cowlitz River tule	33	99	*	Based only on recovery metric.
Elochoman River	4	56	*	Based only on recovery metric.
Germany Creek	30	95	*	Based only on recovery metric.
Gnat Creek	107	195		
Grays River tule	76	164	*	Based only on recovery metric.
Kalama River spring	87	180	*	Based only on recovery metric.
Kalama River	6	58	*	Based only on recovery metric.
Klaskanine River	130	227		
Lewis River bright	5	11	*	Based only on recovery metric.
Lewis River spring	46	120	*	Based only on recovery metric.
Lewis, East Fork tule	3	3	*	Based only on recovery metric.
Lewis and Clark River	934	1,493		
Mill Creek fall	144	258		
Plympton Creek	21	82		
Sandy River late	7	9		
Skamokawa Creek	105	208	*	Based only on recovery metric.
Youngs River	573	732		
Snake River Steelhead				
ESU aggregate	72	291		
A-run aggregate	56	241		
A-run pseudopopulation	56	241		
B-run aggregate	109	370		
B-run pseudopopulation	109	370		

Table 6.3-12 (continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action. "Low" and "High" estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change		
Spawning Aggregation	**Low**	**High**	
Upper Columbia River Steelhead			
ESU aggregate - CRI	47	243	
Methow - QAR	8	146	
Wenatchee/Entiat - QAR	17	96	
Mid-Columbia River Steelhead			
ESU aggregate	122	268	* Based only on recovery metric.
Deschutes River summer	130	270	
Warm Springs hatchery summer	54	54	
Umatilla River summer	53	48	
Yakima River summer	0	10	
Upper Willamette River Steelhead			
ESU aggregate	37	69	
Molalla River	45	108	
N. Santiam River	42	58	
S. Santiam River	30	78	
Calapooia River	53	53	
Lower Columbia River Steelhead			
ESU aggregate	53	171	* Based only on recovery metric.
Aggregations Above Bonneville Dam			
(insufficient information for analysis)			
Aggregations Below Bonneville Dam			
Clackamas River summer	144	376	
Clackamas River winter	75	243	
Green River winter	80	80	
Kalama River summer	51	267	
Kalama River winter	13	58	

Table 6.3-12 (continued). Estimated percentage change in additional improvement in life-cycle survival needed to achieve indicators of NMFS' jeopardy standard after implementing the proposed action. "Low" and "High" estimates are based on a range of assumptions, as described in the text. A value of, for example, 8 indicates that the egg-to-adult survival rate expected from the proposed action, or any constituent life-stage survival rate, must be multiplied by a factor of 1.08 to meet the indicator criteria.

	Needed Survival Change		
Spawning Aggregation	**Low**	**High**	
Sandy River winter	49	108	
Toutle River winter	81	81	
Columbia River Chum Salmon			
ESU aggregate	0	0	* Based only on recovery metric
Aggregations Above Bonneville Dam			
(insufficient information for analysis)			
Aggregations Below Bonneville Dam			
Grays River west fork	0	0	
Grays River mouth to head	18	18	
Hardy Creek	0	0	
Crazy Johnson	0	0	
Hamilton Creek	36	36	
Hamilton Springs	0	0	

Table 6.3-13. Effects of proposed action, current FCRPS operations (shown in **bold**), and other ongoing actions on critical habitat at species-level.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas—Growth/Develop	Adult Migration Corridor	Spawning Habitat
SR spring/summer chinook	- Some habitat (incl. water) quality is degraded by tributary land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish - Some habitat access is depleted by water diversions	**For inriver migrants:** **- Water quality (dissolved gas) declines during involuntary spill** **- Mortality due to passage past 8 FCRPS projects** **- Potential exposure to predators in LCR reservoirs** **- Potential delayed mortality due to FCRPS passage** **For transported fish:** **- Potential delayed mortality** - Hatchery practices potentially lead to adverse interactions with wild fish	**- Potential habitat degradation in plume** - Incidental ocean harvest - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	**- Mortality due to passage past 8 FCRPS projects** **- Water quality (dissolved gas) is degraded during involuntary spill** - Incidental mainstem harvest	- Some habitat quality is degraded by tributary land-use practices and water diversions - Some habitat access is impeded by water diversions
SR fall chinook	**For inriver migrants:** **- Decline in water quality (temperature) during summer and early fall (by heat capacity of mainstem reservoirs) in the Snake River is partially mitigated by cold water releases from Dworshak Reservoir** **- Mortality due to passage past 8 FCRPS projects** **- Mortality in reservoirs due to low summer flows** **- Potential delayed mortality due to FCRPS passage** **- Exposure to predators in reservoirs** **For transported fish – potential delayed mortality** - Hatchery practices potentially lead to adverse interactions with wild fish		**- Potential habitat degradation in estuary and plume** - Incidental ocean harvest - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	**- Mortality due to passage past 8 FCRPS projects** **- Decline in water quality (temperature) during summer and early fall (by heat capacity of mainstem reservoirs) in the Snake River is partially mitigated by cold water releases from Dworshak Reservoir** - Incidental mainstem harvest	**- Unknown effects of flow management on use of spawning habitat below Lower Granite, Little Goose, and Ice Harbor dams** - Irrigation and hydroelectric projects block access to habitat in some tributaries below Hells Canyon Complex - Water quality in lower ends of some tributaries is degraded by land use practices - Hatchery practices potentially lead to adverse interactions with wild fish

Table 6.3-13 (continued). Effects of proposed action, current FCRPS operations (shown in **bold**), and other ongoing actions on critical habitat at species-level.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas—Growth/Develop	Adult Migration Corridor	Spawning Habitat
UCR spring chinook	- Some habitat (incl. water) quantity and quality is degraded by irrigation diversions and tributary land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish	**- Water quality (dissolved gas) declines during involuntary spill** **- Mortality due to passage past 4 FCRPS projects** **- Potential delayed mortality due to FCRPS passage** **- Potential exposure to predators in LCR reservoirs** - Mortality due to passage past up to 5 PUD projects - Hatchery practices potentially lead to adverse interactions with wild fish	**- Potential habitat degradation in the plume** - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	**- Mortality due to passage past 4 FCRPS projects** **- Water quality (dissolved gas) is degraded during involuntary spill** - Mortality due to passage past up to 5 PUD projects - Incidental mainstem harvest	- Some habitat quantity and quality degraded by tributary hydropower development, irrigation withdrawals and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish
UWR chinook	- Some access is reduced and quality is degraded by tributary hydropower and irrigation development and land-use practices	- Water quality degraded by tributary land-use practices	**- Potential habitat degradation in estuary and plume** - Incidental ocean harvest - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	- Water quality and quantity degraded by tributary land-use practices	- Some habitat quantity and quality degraded by tributary hydropower development and land-use practices

Table 6.3-13 (continued). Effects of proposed action, current FCRPS operations (shown in **bold**), and other ongoing actions on critical habitat at species-level.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas—Growth/Develop	Adult Migration Corridor	Spawning Habitat
LCR chinook	- Some access is reduced and quality is degraded by tributary hydropower development and land-use practices **-Access to and quantity and quality of habitat at Ives Island affected by FCRPS flows**	- Water quality degraded by tributary land-use practices **- Mortality due to passage past 1 FCRPS project for a limited number of spawning aggregations**	**- Potential habitat degradation in estuary and plume** - Incidental ocean harvest - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	- Water quality and quantity degraded by tributary land-use practices **- Mortality due to passage past 1 FCRPS project for a limited number of spawning aggregations**	- Some habitat quantity and quality degraded by tributary hydropower development and land-use practices **- Access to and quantity and quality of habitat at Ives Island affected by FCRPS flows**
SR steelhead	- Blockages to tributary habitat are common - Some habitat (incl. water) quality is degraded by tributary land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish	**For inriver migrants:** **- Water quality (dissolved gas) declines during involuntary spill** **- Mortality due to passage past 8 FCRPS projects** **- Potential delayed mortality due to FCRPS passage** **- Potential exposure to predators in LCR reservoirs** **For transported fish:** **– Potential delayed mortality** - Hatchery practices potentially lead to adverse interactions with wild fish	**- Potential habitat degradation in plume** - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	**- Mortality due to passage past 8 FCRPS projects** **- Water quality (dissolved gas) is degraded during involuntary spill** - Incidental mainstem and tributary harvest	- Blockages to tributary habitat are common - Some habitat (incl. water) quality is degraded by tributary land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish

Table 6.3-13 (continued). Effects of proposed action, current FCRPS operations (shown in **bold**), and other ongoing actions on critical habitat at species-level.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas—Growth/Develop	Adult Migration Corridor	Spawning Habitat
UCR steelhead	- Some habitat (incl. water quality) is degraded by irrigation diversions and tributary land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish	**- Water quality (dissolved gas) declines during involuntary spill** **- Mortality due to passage past 4 FCRPS projects** **- Potential delayed mortality due to FCRPS passage** **- Potential exposure to predators in LCR reservoirs** - Mortality due to passage past up to 5 PUD projects - Hatchery practices potentially lead to adverse interactions with wild fish	**- Potential habitat degradation in plume** - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	**- Mortality due to passage past 4 FCRPS projects** **- Water quality (dissolved gas) is degraded during involuntary spill** - Mortality due to passage past up to 5 PUD projects - Incidental mainstem harvest	- Some quantity and quality degraded by tributary hydropower development, irrigation withdrawals, and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish
MCR steelhead	- Some access is reduced and quality is degraded by tributary hydropower and irrigation development and land-use practices	- Some water quality degraded by tributary land-use practices **- Elevated TDG during involuntary spill** **- Mortality due to passage past up to 4 FCRPS projects**	**- Potential habitat degradation in plume** - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	- Some water quality and quantity degraded by tributary land-use practices **- Mortality due to passage past up to 4 FCRPS projects** - Incidental harvest in the mainstem Columbia River and tributaries	- Some quantity and quality degraded by tributary hydropower development and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish
UWR steelhead	- Some access is reduced and quality is degraded by tributary hydropower and irrigation development and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish	- Water quality degraded by tributary land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish	**- Potential habitat degradation in estuary and plume** - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	- Some water quality and quantity degraded by tributary land-use practices - Incidental harvest in the mainstem Columbia River and tributaries	- Some quantity and quality degraded by tributary hydropower development and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish

Table 6.3-13 (continued). Effects of proposed action, current FCRPS operations (shown in **bold**), and other ongoing actions on critical habitat at species-level.

ESU	Juvenile Rearing Areas	Juvenile Migration Corridors	Areas—Growth/Develop	Adult Migration Corridor	Spawning Habitat
LCR steelhead	- Some access is reduced and quality is degraded by tributary hydropower development and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish	- Water quality degraded by tributary land-use practices **- Mortality due to passage past 1 FCRPS project for a limited number of spawning aggregations**	**- Potential habitat degradation in plume** - Hatchery practices potentially lead to adverse interactions with wild fish - Exposure to avian predators in LCR estuary	- Some water quality and quantity degraded by tributary land-use practices **- Mortality due to passage past 1 FCRPS project for a limited number of spawning aggregations** - Incidental harvest in the mainstem Columbia River and tributaries	- Some quantity and quality degraded by tributary hydropower development and land-use practices - Hatchery practices potentially lead to adverse interactions with wild fish
CR chum	- Some quality is degraded by tributary land-use practices	- Water quality degraded by tributary land-use practices **- Unknown mortality of smolts due to passage past 1 FCRPS project**	**- Potential habitat degradation in estuary and plume** - Exposure to avian predators in LCR estuary	- Some water quality and quantity degraded by tributary land-use practices **- Unknown mortality of adults due to passage past 1 FCRPS project** - Incidental harvest in the mainstem Columbia River and tributaries	- Some quantity and quality degraded by tributary land-use practices **- Access to Hamilton Creek and Spring Channel affected by FCRPS flows** **- Access to, quantity of, and quality of habitat at Ives Island affected by FCRPS flows**
SR sockeye	- Access is reduced and quality is degraded by land use and tributary hydropower and irrigation development	**- Mortality of smolts due to passage past 8 FCRPS projects** **- Potential exposure to predators in reservoirs**	**- Potential habitat degradation in plume** - Exposure to avian predators in LCR estuary	**- Mortality of adults due to passage past 8 FCRPS projects** - Incidental harvest in the mainstem Columbia River and tributaries	- Quantity and quality degraded by tributary land-use practices